The Electrical Solicitors' Handbook

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New York
1909

Second Edition

Hill's Print Shop, New York

The National Electric Light Association
1909–1910

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A WORD OF EXPLANATION

Credit for *The Electrical Solicitors' Handbook* belongs to the spirit of co-operation carefully fostered by the *National Electric Light Association* and now prevailing so extensively in the electrical industry. The *Handbook's* more immediate inception occurred in the program formulated by the Co-operative Electrical Development Association under the guidance of Mr. J. Robert Crouse. It is the composite work of twenty contributors.

Prizes for the best papers on the subject of electrical solicitation, aggregating $2600 in cash, were contributed by the Co-operative Electric Development Association, and were awarded by a special committee of the *National Electric Light Association*, consisting of Mr. John F. Gilchrist, *Chairman*, Mr. Percy Ingalls and Mr. George Williams, at the Chicago Convention of 1908. Nine awards were made, three going to Mr. R. Borlaise Matthews, jointly with Mr. C. T. Wilkinson, and two to Mr. James L. Wiltse. The names of those receiving awards are as follows:

Mr R Borlaise Matthews — London England
jointly with
Mr C T Wilkinson — Schenectady New York
General Electric Company

Mr James L Wiltse — Brooklyn New York
Edison Electric Illuminating Company

Mr H W Hillman — Grand Rapids Michigan
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Mr La Rue Vredenburgh — Boston Massachusetts
Edison Electric Illuminating Company

Mr Paul H Bate — Chicago Illinois
Commonwealth-Edison Company

Mr C A Graves — Brooklyn New York
Edison Electric Illuminating Company

In making the awards, the Committee stated that, while nine manuscripts had received prizes, much of value was to be found in the remaining contributions. The names of the contributors entitled to honorable mention are:

Mr F P Catchings — Atlanta Georgia
North Georgia Electric Company

Mr Harry P Chandler — Newark New Jersey
United Electric Company of New Jersey

SECTION 1

[E ELEMENTS OF CENTRAL STATION BUSINESS GETTING

INTRODUCTION

:t is not the intention in these hints to solicitors to ιt any length on those **qualifications** which are essential make-up of the successful solicitor in all lines, such as ng good humor, affability, a pleasing address, ability pt oneself to circumstances, industry and perseverance n intuitive consciousness of the point where persever- eases to be a virtue and becomes a nuisance. It is ed that these general good qualities are already pos- by a solicitor, but in passing it may not be amiss to .te that the successful salesman is the one who can plish two things. First, convince a consumer that ιts the commodity for sale, and second, prove to him e can afford to buy it. When either of these is an ex- :act, the salesman has half his work done for him. In eat majority of cases the salesman of electric energy deal with people who want his goods; consequently ›lves upon him to prove that they can afford to buy.

:here are certain prominent subjects with which the ›r should be familiar, and which he should constantly ι mind. A few **suggestions** and hints as to which are ›st important points will be given in the following para- ;. It must be remembered that arguments which in one neighborhood or under certain circumstances ιot do so in another. The solicitor must use his ιer wit," and compile and adapt further arguments is experience. The art of soliciting cannot be taught and entirely by any book, however fully it may enter etails. In *this*, as in many other cases, experience :.

HOW TO MEET OPPOSITION AND COMPETITION

3. The reason which above all others retards a rapid advance in the use of electrical energy is found to be the **widespread ignorance** that prevails concerning its advantages. Therefore, it is of primary importance to educate the public in this direction, and so overcome the prejudices and mistaken ideas to which such ignorance gives rise.

4. As regards the part which the solicitor must play in the **removal of this general ignorance**—it is, of course, necessary that he should himself be honestly and thoroughly convinced of the real economy and numerous advantages which may be secured through the use of electricity; otherwise his words will carry very little weight with prospective customers. There will be little difficulty in this direction, for, with the solicitor as with the general public, "to know is to appreciate," where electricity is concerned. A careful investigation of the claims of electricity will soon prove to the investigator that such claims are not unfounded. Electricity speaks for itself. The great object is to bring the public into experimental contact with it. Let people see what their neighbors are doing by its means, and they will try it for themselves, for with the majority the old saying, that "seeing is believing," still holds good.

5. The solicitor for electricity has an easier task in some ways than men who are employed in selling books or insurance or stocks, for the latter have to urge an investment in that which is not altogether desired. Electricity, however, interests every one, and is to a certain extent desired by every one, except for the general exaggerated idea of its cost and the notion that its superiority in quality is not such as to counterbalance this extra expense. These ideas can be easily proved by the solicitor to be merely due to a lack of appreciation, both of its many specific advantages, and also of the modern methods for applying it economically. That people should continue to hesitate to make use of electricity when they have been clearly shown its many advantages would be indeed surprising.

6. The arguments brought against electricity can easily *be refuted.* It will sometimes be found, however, that the *man whom the* solicitor is trying to convince is merely making

such arguments an excuse to hide the real hindrance, namely: the **lack of money to meet the cost of the installation** of the wiring; when this is perceived to be the case, the solicitor should suggest any plan of rental which his company has arranged. If this fails to bring results, the only way is for the solicitor to try to persuade the landlord to install the wiring. Or perhaps the tenant's objections may be due to the fact that he does not intend to remain much longer in that house. Naturally he does not wish the landlord to hear of his intentions in any roundabout way, and therefore he does not tell the solicitor his real reason for not wishing to adopt electricity. This, again, is a case when the only hope of getting the house wired lies in persuading the landlord to have it done.

7. One of the great **difficulties with which solicitors have to contend**, especially in power work, is that a prospective consumer, with that little knowledge which is so dangerous, will inquire how many watts a piece of apparatus or lamp will take; he will then multiply this number of watts by the total number of working or lighting hours, as the case may be, in the year, thus obtaining the total watt-hours; he will then divide by a thousand, in accordance with the instructions given him, and so obtain the total kilowatt-hours, which result in turn he will multiply by the price per kilowatt-hour, and obtain a figure which, to say the least, is startling, and in his opinion out of all reason. This must at all costs be avoided by pointing out that the apparatus only takes the number of watts given at full load, and that full load is only taken on very few occasions during the working year, the average load probably working out at something less than thirty per cent of the maximum as calculated. A statement of this nature must, of course, be upheld by the evidence of other consumers' bills.

8. The chief **competition** that the solicitor will have to meet is that provided by the **gas company**. The other illuminants and means of obtaining heat and power, such as oil, acetylene, or that latest arrival, gasoline air gas, are not very serious competitors, since, as a general rule, there is no one whose business it is to advocate their use in season and out of season.

9. ***The solicitor's standing as regards the gas company***

should be a dignified one; it does not pay to run gas down especially to a customer who refers to it. The very fact that gas is mentioned shows that it has received consideration, and has been considered equally, or almost equally, with electricity. If the gas company's product is belittled or sneered at by the electrical solicitor, it does not add anything to the prestige of electricity, but rather serves to indicate that gas is feared by the electric company, and the impartial man is therefore inclined towards the belief that gas is practically as good as electricity. If it is necessary, the prospective customer may easily be led to deduce the drawbacks of gas for himself, through the solicitor's simply mentioning the fact that electricity does not spoil ceilings and decorations, does not consume oxygen, does not necessitate the use of matches and does not endanger life by explosions and asphyxiations.

10. Gas advocates are rather given to the habit of **comparing** the latest type of **gas lamp** — the Welsbach burner — **with** the oldest type of **electric lamp** — the glow lamp about as sensible and fair a comparison as that of putting the newest and most efficient forms of electric lamps alongside the old flat-flame gas burner.

11. In figures published by various gas companies the cost of lighting by electricity has been made out to be anything from two to twelve times that of gas.

12. Since there is this great range of opinion, or rather doubt, as to whether electricity is two, twelve, or some intermediate number of times as costly as gas, an impartial observer will appreciate the fact that there must be a discrepancy somewhere, and that in all probability the greater the relative cost of electric as compared with gas lighting, the greater the fertility of imagination on the part of the author of the statement.

13. Where actual figures are not propounded it is often airily stated that "it is a matter of common knowledge that gas is cheaper than electric light." It might be more accurately styled a "matter of common **ignorance**." It is one of those convictions which the evidence of annual accounts will alone dispel.

14. Still, in spite of these numerous drawbacks, to absolutely deny that gas possesses any advantages would be *senseless. Until* electricity appeared on the scene, gas filled

a useful place. But to continue using it when something better is to be obtained is even more senseless. Electricity is as far ahead of gas as gas is ahead of oil, candles, or coal for obtainance of light, heat, and power. Then why not use electricity? The reason is not far to seek.

15. It is chiefly on account of the **slow movement of public opinion**; electricity is a newer thing than gas and is therefore, like all new things, regarded with more or less suspicion. The majority of people have a great dread that they may be "flying to ills they know not of," when anything new is advocated. The arguments which are now being used against electricity were a few years ago used against gas. Now the public has become, to a certain extent, hardened to the dangers of gas. Accounts of gas explosions and gas asphyxiations are read with horror, but no one ever imagines that such an accident might as readily happen to himself.

16. "Use is second nature," and yet gas people will say that gas is safe, and that "gas will not burn unless a light is applied, and therefore there can be no fire without an externally applied light." Agreed. Gas resembles gun cotton in this respect. It is astonishing, however, how often that external light gets there.

17. If ever anything better than electricity is discovered, it is fairly safe to prophesy that the same old arguments which have done duty so long will appear once more, but in favor of electricity as against the new discovery.

18. There are many warm supporters of the **gas engine**, but it is but a poor sort of thing now that electric motors are in the field. It requires several times the attention, wears out its parts at a lamentable rate, needs continual overhauling, and emits disagreeable odors. It gayly snorts and clanks away from morning till night, using an amount of gas out of all proportion to the useful work when running at anything but full load, and should it by chance be somewhat overloaded, promptly strikes work with the airy independence of the mechanic who is employed to nurse it.

19. What a picture to compare with the neat little motor working silently away and reminding its owner of its presence only when he marvels at the extreme reasonableness of the bill presented by the central station.

20. The electrical solicitor must bear in mind the fact that

the gas interest can by no means be classed as "asleep." On the contrary, it is wide-awake and on the watch, as is testified by the eager way in which it grasps at any good ideas originated by electricians and promptly adapts them for its own use. "Imitation is the sincerest form of flattery," and the electrical industry has plenty of this kind of flattery to fight against. Witness the inverted gas burners, designed to give a downward light, the artistic fittings for these burners, modeled along the lines of electric fittings, their thin neat tubes deceiving many people into the belief that they actually are electric light fittings, also push button control systems for lighting the gas, operated pneumatically or electrically, by touching a button placed in the same position near the door as that in which an electric switch would be found. There are also luminous gas stoves designed to look like luminous electric radiators. All these dodges show that gas agents realize the superiority of electricity and the importance to them of keeping up with their rival in appearances if they cannot in the solid advantages which electricity has to offer.

21. Of course, gas will never be entirely removed from the field it has held so long; it is against natural laws that it should be, for no one thing can ever be a panacea for all ills, but the obvious advantages of electricity cannot but largely remove any handicap in its competition with an established system.

22. The electrical solicitor must be thoroughly familiar with modern **means and methods of illumination**, he must have the facts on the tip of his tongue at all times. One of the great arguments in favor of electricity is its extreme adaptability to the varied demands of usual and unusual circumstances. In show window lighting and signs, electricity stands alone, no other illuminant being able to compete with it. It is a case where price can be left entirely out of consideration. Storekeepers must have electric light for these purposes at almost any cost. The way to make this stronghold still stronger is to take the utmost advantage of the possibilities of electric lighting for show windows by utilizing methods of concealed lighting. Gas lighting, regarded merely as light, leaving other considerations out of the question, can always compete, fairly well, with electric lighting, as long as a row of naked lamps staring the passer-by

in the eye is considered good enough for show window illumination.

23. Some notes on the subject of lighting are given in Section 3. They should be carefully studied, and also any text-books dealing with electric lighting from the illumination point of view. The effect of various methods of lighting in various stores should be noted for future reference and guidance. Also figures should be collected as to the cost of the wiring of show windows, and the prices of special fittings.

24. A very important thing to bear in mind is that the **public is buying light**, and has no feeling for energy, and if the public gets what it wants at a reasonable price, it won't quarrel over the price per kilowatt-hour, hence the importance of advising customers as to the most efficient way of using the electric energy they buy. The efficiency and life of particular lamps have, of course, an important bearing on the whole matter. It is a mistaken notion to think that because a man is using very efficient lamps the central station will lose money; it will temporarily, but in the end it will gain, for if a man finds his bills low at the start, he becomes satisfied with electricity, and later on when the solicitor comes along with a suggestion for an improvement of the lighting arrangement, he is willing to consider it, and will do so on a fair basis, realizing that for more light the bill will of course be a little higher. A man who is brought to adopt electric light in this fashion becomes a satisfied consumer and a perpetual recommendation; and at the same time the central station is well recompensed for the trouble taken.

25. The solicitor needs also to be up to date in his knowledge of modern methods for using electric motors. For outlines of these, refer to Section 5.

26. In the **application of electric motors** to do work formerly carried out by some other means, the motor should not merely be put in its place, but on the other hand, the whole proposition, carefully considered so as to ascertain what can be eliminated in the way of friction losses, floor space occupied, light obstructed, and how full advantage can be taken of the flexibility of the motor drive, in order to insure that the machinery to be driven, will be arranged in such a manner as to facilitate the work done. Any economy effected and advantage gained in this direction will be

credited to the motor drive, so again it is to the advantage of the central station to render what assistance is possible in this direction when a motor is installed anywhere.

HOW TO APPROACH THE PROSPECTIVE CUSTOMER

27. The solicitor should try to get upon a friendly basis with all prospective customers by taking an interest in what interests them; even subjects so apparently remote from electricity as baseball or golf, stocks or shares, may be very useful as a means to gain the desired end. For **the man with a hobby** appreciates an attentive listener. By the way, if anything is brought up in the course of conversations either on these or on technical topics, which the solicitor does not understand, it is wiser for him to ask a question than to pretend to have an intimate knowledge of the subject, for his ignorance will soon be discovered, and it is then more than likely that his electrical knowledge will be put on the same par, his statements discounted, and his figures doubted.

28. When a solicitor is talking to a **non-technical man**, he should avoid all technical terms such as "amperes" and "volts." The ordinary man neither knows nor cares much what an ampere or a volt is. What vitally affects him is the bill he will probably have to pay for the amount of light or power he requires. Therefore it is excellent policy, when the question of cost comes up, to ignore the price per kilowatt-hour, giving in place of that an estimate of the monthly, quarterly, or yearly bills, backing up the estimate by the actual bills of people whose conditions of use are similar to those of the prospective consumer.

29. The only time a solicitor should be technical is when he is talking to **technical men**. He should then lay himself out to see what they are driving at and take an intelligent interest in their views. If those views seem somewhat unsound, there is no need for the solicitor to go out of his way to point it out. No man likes even implied contradiction; and besides there is a chance that he is right after all.

30. Some one has said that "**human nature** is a cur'ous critter." The more a solicitor knows of this "cur'ous critter" and i[illegible] he more successful he is likely to be.

He will meet with many phases of it, and must learn to act accordingly, to distinguish between the various classes of people; some he will find are of conservative tendencies, prejudiced against all that is new; others are procrastinators, admitting the solicitor's arguments, but delaying a decision; others again belong to the class of people who live up to the limit of their incomes, and do not pay their bills except under pressure. Such cases as the last are hardly worth the time wasted in interviewing them. The solicitor needs to use his discretion. The feelings and customs of the householders must be studied. It is usually better to arrange to see the lady of the house first, and it is well to send a notice the day before so that she and her house may be prepared to receive the solicitor. When the lady is convinced, then is the time to make an appointment to meet the master of the house, for he will now be prepared to listen more readily to the solicitor.

31. In interviewing the lady of the house it is a good plan to mention what her neighbors are doing, and so play upon her social pride, insinuating, in a delicate way, that if they can afford it, she can. Explain how Mrs. So-and-So has now a lovely electric kettle for her afternoon teas, and Mrs. S. O. Else has a hot plate which she uses at all meal times, and declares she "could not live without"; that Mrs. A. N. Other is delighted at the scope it gives her artistic temperament to be able so easily and safely to add to the decoration of her rooms by means of her electric light fittings.

32. Before making a **canvass in any street** the solicitor should make a careful note of the information concerning existing consumers in that street, as it appears on the main card file. First, so that an existing consumer may not be asked if he would care to put electricity into his house, and second, so that the solicitor may be fully informed when he calls upon an existing consumer as to what his installation consists of, and what he needs, and thus please him by the interest taken in him and the attention given him.

33. There is a matter that should at least be referred to, and that is the question as to the advisability of taking a prospective customer to a convenient **hotel bar or club to discuss business affairs**. A solicitor need not be a teetotaler, — *that has nothing* really to do with it, — but if

cannot obtain an order from a man without first getting him into an hotel and buying him drinks, either that man is not worth getting or the solicitor is lacking in some of those qualities which it is essential he should possess. Again, an invitation of this kind will often offend people who do not resort to such ways of doing business, and it will not do the solicitor any good with the man who asks him to drink. It is much easier to get a reputation as a frequenter of hotel bars than as a successful business man.

34. After all, business is business and pleasure is pleasure. One or two drinks will not carry much weight in the placing of an order.

35. The solicitor must be provided with a certain amount of **ammunition** before he makes his call; he may or may not be a technical man, but he must be thoroughly coached and posted in those matters with which he has to deal, for it is fatal if the prospective customers realize that they are talking to some one who does not know much more about the electrical business than they do.

36. Among the information the solicitor should have at his disposal is data showing the **average bills** of customers, their kilowatt-hour consumption per equivalent 16-c. p. lamp connected, the cost of lighting various size lamps per hour, and the cost per hour of operating various heating and cooking devices.

37. The **general policy** that should be adopted **in canvassing** is to see that the customer gets what will be most economical and serviceable, as this is the policy that pays best in the end, for though the load at first is not as great as it might be, it means the obtaining of a satisfied customer, who is a valuable asset.

38. Eventually, as soon as the consumer finds that his bills are reasonable, he will use electricity for other purposes, which is what the central station manager desires.

39. The way should be prepared as far as possible by suitable advertising matter, and the day before a call is made a postal card should be sent making mention of the fact, thus paving the way for a favorable reception.

40. The **most likely places** should first of all be attacked — the stores in the main streets and the factories, then the smaller stores and larger residences should receive attention,

nd so on until the whole city is canvassed. The solicitor, fter making a call, should not omit "to leave his card." 'he card suggested as advisable would be a postal card ddressed to the central station, and having on the back a rinted request for a representative to call, spaces being eft for filling in the time and the day which would be most onvenient to the sender. This card, if placed by the solicitor on the telephone, or other convenient and prominent lace, will at least serve as an advertisement and reminder of he existence of his department, even if it is never actually osted.

41. It is a noteworthy fact that a reduction of rates will ot increase business as much as systematic canvassing does. 'he moral is obvious.

42. Residence Soliciting. — The reason that many people do not wire their houses is chiefly on account of the fear hey have that the cost of so doing will be out of proportion o the advantages derived; hence the importance of dispelling any illusions they may have on this point as soon as ossible. The majority often do not even ask what the rate s; what they generally want, however, is an estimate of heir probable monthly bill. They do not understand the ates as a rule, and knowing that the prices are the same to very one, are satisfied if their neighbors use it the charge nust be all right, so that to them it is all a question of installation cost.

43. If the solicitor has with him illustrations of some of he principal components employed in **house wiring**, it will id much in his explanations of such things as the difference etween side brackets, drop lamps, pendants, and electroliers; etween flush, pendant, and ordinary wall switches, and the nany other devices which play their part in enhancing the onvenience of an electric service.

44. In this connection good use could be made of illustrated pamphlets to give general and popular information oncerning the methods of wiring houses, the location and rrangement of fixtures, switches, etc.; the use of two-way nd three-way switches for hall and staircase lamps; the conomy arising from the use of a pilot lamp for cellar amps; the increased cost of concealed over surface wiring; he possibilities of the electric motor for driving the se

machine, the meat chopper, the washing machine, and the mangle. Also general details of electric heating and cooking devices. Attention should be specially drawn to the fact that the wiring of a house does not involve the mess made by plumbers or gas fitters, and that it does not mean the pulling of the house to pieces or the damage of valuable wall papers.

45. In residence canvassing it is well to endeavor to be allowed to estimate for wiring the house. The specification should be prepared in two ways, one with the wiring done in the way that best suits the ideas of the householder, and the other in such a manner that the figure is reduced as much as possible, by omitting all lamps but those which are absolutely necessary, confining the lighting to the living rather than the sleeping rooms, and thus give an idea of the minimum price an installation could be put in for; the lower figure also shows up the difference between necessity and convenience, and presents in a somewhat better way, what at first may appear to the average householder to be a very high figure, — the householder being usually unacquainted with the cost of installation work, whether for electricity or gas. Chandeliers and other fixtures should always be figured as extras, as taste varies so much in the selection of these fittings, and their price, added to the cost of wiring, makes the latter appear excessive. It must be remembered that existing gas chandeliers can often be wired at a small charge.

46. A **standard form** should be prepared for use in getting the **wiring data** together, to insure that nothing is omitted, and also to see that if the work is bid upon by more than one contractor, they base their estimate on the same specification.

47. As a rule, it will be found best that the solicitor should not make an estimate at the time of calling, though it is well that he should be able at times to give an approximate figure, making it quite clear to the prospective customer that this is so, and at the same time mentioning that an accurate figure will be presented in the course of a few days.

48. Having exhausted all arguments without succeeding in getting a tenant to wire, an attempt should be made to get him started with a **partial electric service,** — something that will be universally appreciated, such as a porch lamp, which might be taken on a flat rate, for lighting up to, say, eleven

o'clock in the evening. Flat rates as a rule, however, should be avoided, as they are extremely unsatisfactory both to the central station and the consumer, and lead to much bad feeling; in the case mentioned it is not so objectionable, as it is more of an advertisement.

49. The result of the installation of a porch lamp is that soon a lamp will be asked for in the hall; then is the opportunity for putting in a meter. The thin end of the wedge having been introduced, it will not be long before the occupant wants the rest of the house wired for electric light.

50. Another scheme worthy of consideration for getting electricity into a house is to make arrangements to install an electric flatiron, a sewing machine motor, or fan.

51. Store Soliciting. — In canvassing stores the data as to the average, the maximum and the minimum consumption per equivalent 16-c.p. lamp connected, are very valuable, since in the case of any proposed lighting scheme, the monthly or quarterly bill can be fairly accurately estimated from these figures for stores doing the same class of business.

52. The **electrically illuminated sign** forms an exceedingly good advertisement for the storekeeper, and at the same time is a good source of income to the central station. Therefore the solicitor should be supplied with sketches of suitable signs, figures as to the cost of the sign, the cost of installation, and the cost of operation.

53. If the central station management has arranged any special terms for the renting or purchase of signs, the solicitor should make himself well acquainted with the terms, and also the types of signs supplied under such terms, so that he may be able to put them before possible users in a clear, definite manner.

54. Propositions, however good, will amount to very little if the prospective sign customers are ignorant of them. It is one thing for a canvasser to know that he can make certain concessions and inducements in favor of electric sign users, and another thing for the man who might thereby be influenced to put up a sign to realize these facts. The questions of advertising and salesmanship should therefore figure very prominently in all plans for increasing the number of the signs on a distributing system. The average storekeeper not only does not realize what propositions are avail-

able to suit his case, but he has not even thought of installir such a thing as an electric sign. He has to be educated t the value of the electric sign in commercial life, starte thinking about it, and then have the matter brought to hi attention again and again.

55. The use of signs, properly encouraged, will not onl mean the lighting of the same from dusk to the shop closin hour, but will eventually result in their being kept lighte until about eleven o'clock, — that is, to the time of nigh after which all the people will have gone home when th various entertainments are over. This after closing hou illumination of signs and show windows is gradually begin ning to be appreciated as a valuable feature by storekeeper all over the country, since it is realized that, though the store are closed, there are many passers-by whose attention will b drawn to the store by the sign, and to the articles displaye by the lighted window, bringing to their attention man wares that might not otherwise have been known abou This form of advertising appeals to the people that the store keepers are anxious to reach, people who are occupied b day and are unable to visit the stores to select or mak purchases, except on the one or two late closing nights c the week.

56. In conjunction with an aggressive electric sign cam paign arguments should be advanced and suggestions mad to the storekeepers to the effect that in this advertising ag the day of the shuttered store has passed. It is difficult, c course, to displace long-established customs in favor c what apparently appears to be such a radically dangerou move as leaving the store windows unprotected at nigh after the store has been vacated. As a matter of experience however, the **danger of burglary** is much **lessened**, especiall when the practice is adopted of leaving a single lamp burnin all night so that the police and other passers-by can easil see inside the store from the street, as in that case it make the risk of detection to a burglarious person who has entere from the rear of the premises so much greater. The pre mium required, in any case, by insurance companies wh make a specialty of insuring against burglary is not grea and is far outweighed by the value obtained from th *advertisement.* Many stores, though not shuttered, sti

draw down their blinds when closed, and thus lose valuable advertising opportunities, which fact must be brought home to them; and they should be the more easily convinced, since they already appreciate that it is not necessary to use shutters.

57. In the general scheme of the lighting of stores it cannot be too distinctly explained to the owner of the store that that portion of the light used in the windows is really light-advertising, and that in the consideration of the amount of money that is to be expended on electric energy consumed there, this fact must be fully taken into account.

58. The **smaller stores** are very well worth looking after, and though the income from them individually may not be very great, they form a very good advertising medium for the central station, and are of importance from their very numbers. The small store proprietor is, naturally, more appreciative — more talkatively appreciative than some of the larger business houses. Then again, it is but a step from electric light in the store to electric light in the home of the proprietor. And so on, from his house to the homes of his neighbors and friends, the good work invariably goes on, forming a chain of new adherents, which is, or ought to be, welcome to the central station.

59. The small storekeepers are not apt to rush down to the central station, begging for information on the question of electric light; more probably they have not even considered the question of proper illumination, having plenty of troubles of their own to occupy them. Therefore, it is especially necessary for the central station to lay itself out for canvassing them.

60. The installation of electricity, where it has not been used before, serves as an example, an invitation for others to follow suit, for it is written in the books that a pleased customer does not keep still, but rather talks among his neighbors and fellow-tradesmen.

61. When the small stores, as well as the large ones, begin to use electric light, people generally appreciate that electricity is not a thing set apart for the well-to-do only.

62. Almost every line of human endeavor is suggested by example. Every evolution grows into an accepted institution by somebody initiating it, and others following. No

matter how many stores are using electric lighting, if that electric lighting does not demonstrate that it is superior to oil or gas, it cannot, and will not, stimulate other stores to install electricity.

63. Of course, almost any form of electric equipment is better than oil lamps or gas, but is it not better to induce every store in a city to discard its old-fashioned system and put in a modern electric installation?

64. The better the example in the stores that are now electrically lighted, the more convincingly will electricity appeal to the stores that have not got it. Hence the argument that the central station should assist in the lay-out of the illumination scheme for these stores is a very strong one.

65. **Industrial Soliciting.**—This form of canvassing is much more difficult than the canvassing of residences and stores. It requires, if it is to be handled successfully, the services of a trained technical man. In the power business is to be found the most paying load of the station, for though the rates obtainable are not high, the demand is spread over a large part of the day. There is not so much difficulty in obtaining power customers where the motor capacity required does not exceed 15 hp.

66. Up to 5 hp. electricity has got the field pretty well to itself, being so convenient and the only practicable means. Even at a comparatively high rate per kilowatt-hour the total bills work out at a very reasonable amount.

67. The **small energy user** often does not use electric energy simply because he does not realize that it can be applied in his particular case, so that it is necessary to bring examples of motor applications to his notice, and make suggestions as to how he could also take advantage of the same energy. He is also interested in the cost of such energy, and in what his neighbors are doing and paying. Data should be collected of various machines that are specially built for direct driving by motors, for such apparatus is usually more satisfactory than that which is driven by belt. For instance, many grocers, rather than operate their old hand coffee mill by a separate motor belted to it, would invest in a modern direct connected mill, if they only knew of the existence of a neat, efficient, and compact machine.

68. By the exercise of a little ingenuity, and taking every

opportunity of observing the methods the various tradesmen have of carrying on business, a large number of possible **applications for electric motors** can be discovered. A small motor does not consume much, but collectively a large number of them provide a very satisfactory load, which at the rates paid is not by any means to be despised. While looking out for this small motor business, electric heating should not be overlooked. The electric flatiron has a field of its own in dry-goods stores and tailoring establishments. No case should fail of investigation, for conditions cannot be fully understood until after careful investigation, which often develops surprises. Even lumber yards burning refuse wood for fuel purposes at times find it advantageous and profitable to use central station service. In some localities a satisfactory market can be found for refuse wood, thus actually opening up the way for complete central station service. In other instances lumber yards find it good business to take central station service for extra work, or for work beyond the capacity of their installed engines.

69. Wherever the **load factor is high**, the average load for 24 hours a day standing high in relation to the maximum demand, opportunity is afforded for allowing the lowest rates of charge for energy, and many such cases therefore come within the reach of central station service. Wherever the friction load is heavy, but can be materially reduced by cutting out shafting and belts, through the substitution of a number of motors, the way is opened for central station service.

70. Wherever the **use of energy is occasional** or at irregular intervals, as in the case of building elevators, large metal shears, cold metal saws, cranes, etc., it is plainly much cheaper to operate motors on central station service than to run a steam or other engine, including the cost of necessary attendance on the latter.

71. The best **method of dealing with the power situation** is to investigate the conditions in each factory by turn, making tests where possible. The owners are usually quite willing to grant permission for this. Some factory is certain to be reaching the point of overload of its own power plant, or possibly a breakdown occurs; this affords the opportunity *for the central station.* A motor is installed on trial — the

inevitable result follows, another motor goes in, until at last, after much expenditure of time, trouble, and attention on the part of the central station management, the whole plant is motor-driven, and then affords an example for other factories.

72. The installation of a **motor**, say, **on a 60-day trial**, is almost invariably a safe risk to undertake. Under these conditions the best method of installation must be insisted upon and every effort made to insure the most economical results, by taking full advantage of the flexibility of a motor drive and the possibility of cutting out all unnecessary line shafting — for the greater the economy effected, the sooner is the user convinced of the good value of central station service.

73. Here, again, data as to the **energy consumption** of other customers are of great importance. These should be tabulated under headings similar to the following: (1) kilowatt-hours per month; (2) connected load in horsepower; (3) individual or group drive; (4) number of motors; (5) percentage of average load to connected motor load.

74. Prospective customers always wish to know what it is going to **cost** them **per month** or per annum to run a particular motor, and usually multiply the full-rated horsepower of the motor by the number of working hours and by the rate charged for energy, which naturally gives an excessive figure. Now tables, prepared in accordance with the suggestion made above, will indicate that the average load on a motor rarely exceeds four tenths of the rated load, and more usually is in the neighborhood of one third of that load.

75. Very often **steam and other heating systems** play a very important part in the operation of a factory, so at the time a motor installation is made it is well to look into this part of the factory economy also, to see that all leaky pipes are calked up and proper steam traps used on all drains. Suggestions should be made for the improvement of heating apparatus if possible. Even such a simple idea as to install double windows during the winter months makes quite a difference to the coal pile. Thus, indirectly, the introduction of the motor drive is associated with a general reduction of manufacturing costs, for which the motor drive takes the *credit.*

76. Circulars and pamphlets bearing on the use of electrical power in factories keep the manufacturers' interest alive. Illustrations of various applications of motors, though not dealing with the particular business the manufacturer may be interested in, will cause him to think of some machine in his own business to which a motor could be applied in a similar way. As the number of booklets required is small, the cost of producing special advertising publications for power users is proportionately greater than in the larger field of residence and shop lighting, so advantage should be taken of the pamphlets and leaflets issued by the manufacturers of motors, who are usually glad to forward copies for distribution. The special folders and booklets prepared by the various advertising specialists are also very useful.

77. The **testimony of a well-pleased customer** is often of great service in bringing to the point of decision a man who is still hesitating as to whether he shall use electric energy or not; so that if the prospective customer can only be persuaded by the solicitor to go with him to see the well-pleased customer, the latter will probably do much to convince him; his words will have very much more effect than those of the solicitor, as the possible customer appreciates that he has no "axe to grind" or commission to earn, so that his evidence will be impartial and unbiased, and, therefore, worthy of careful attention. Moreover, in so doing, the solicitor will make a better friend of his pleased customer, for it is a well-known fact concerning human nature, that no one ever did a favor for a man without liking him better than he did before. The customer also appreciates the delicate flattery of an appeal to his sound business judgment in having, after due and careful consideration, decided to install an electric drive.

78. Undoubtedly the **individual driving** of machinery should be advocated, whenever feasible, so that utmost advantage can be taken of the economy arising from the elimination of the friction losses of belting and shafting. The saving of energy in this way often amounts to a considerable item, which assists largely in the arguments as to the superiority of electric driving over other methods. Too much emphasis should not be placed upon the saving to be effected in this way, for it is not enough merely to show a man that by *dispensing with belting* and shafting, and putting in individual

motors, much of the energy now being dissipated could be saved; the question must be treated in its broader sense of the total reduction in cost to be anticipated by the use of central station energy, otherwise, by not taking all the factors into consideration, the prospective customer may follow the solicitor's advice to the extent of installing an individual motor drive, but may then proceed to operate it with his own generating plant, instead of using the central station service.

79. Like many other good things, individual motor driving can be carried too far, not so much in the electrical sense, for the difference in efficiency of modern electric motors at light and full loads does not amount to a very serious item, but from the point of view of the capital investment in the motors, the interest on which is as much an operating cost as the energy consumed.

80. One great difficulty that confronts the solicitor is the question of the prospective power user as to **what** he is **to do with** his **existing power plant**. It is not easy to show some manufacturers that although they may have charged the entire cost of such plant to their depreciation account, and it is not now represented by any value in their books, yet the cost of fuel and maintenance is in excess of the cost of operation plus the interest of the investment and depreciation of a modern installation. Each case of this kind has, of course, to be separately considered and careful tests made of the existing plant. In all probability some arrangement could be made on a guarantee basis, to the effect that, during the first year of operation, the charge for energy should not exceed the present cost of the obsolete plant. After an investigation in cases of this kind, certain motor manufacturers are prepared to coöperate with the central station in supplying the motors on a rental basis, agreeing to take the motors back should the cost of the service prove to be very much in excess of that estimated. The usual result of such a test is that the motors stay in.

81. It is advisable to render every possible assistance to a prospective customer in the disposal of his old power plant, for the sooner it is sold, the sooner the central station is assured of a new customer. It need hardly be remarked that it is well to endeavor to make the sale outside the area supplied by the central station.

BUSINESS-GETTING SYSTEM

82. The keynote of modern successful business is system, and in these days of keen competition the more perfect the system, the more prosperous the business. In soliciting it is very essential that a good system be employed, for, intelligently handled, it will be the means of saving much time and labor.

83. When the general scheme of the system to be adopted has been worked out, a general **instruction book** should be prepared containing notes on the schedule decided upon and copies of instructions relating thereto. Such a book should be of the loose leaf form so that fresh instructions can be added in their correct place from time to time, as the system develops in its details. It is advisable to maintain duplicate copies of this book, one for general use and the other for the manager's reference. A book of this description will prove of great value and assist generally in the smooth operation of the system.

84. Advantage should be taken of those **modern office methods of keeping records** — the vertical file with a separate numbered folder for each name, and the card index. One standard size of card should be used, preferably the 6 in. by 4 in., of thin material, so that it can be easily used in the typewriter.

85. Each customer should be allotted a number, to facilitate reference to the records of the accounting department, correspondence, installation data, etc. To the rotation number should be added a letter to indicate whether the building occupied by the customer may be classed as (R), a residence, or (S), a store or business place, or (P), a place where power is used.

86. The first thing that should be done in the actual work of soliciting is the compilation of a card index of existing customers, as it is essential that accurate information should be on hand ready for the time when the question of an increase in the lighting or power load has to be considered, and also to satisfy the queries usually put by a prospective customer as to what his neighbor is doing. Solicitors by referring to this list can avoid the error of canvassing existing customers. *This index should be* arranged in alphabetical and numerical

order of the streets of the city in which the building is located, and not according to the initial letter of the customer's name, or the number that has been allotted to him, since from the point of view of the supply of energy, the building is the permanent feature and the occupant merely temporary. On the same card should be placed the customer's rotation number and a note as to his connection in equivalent 16-c. p. lamps and in horsepower of motors installed. The cards should be distinctively marked by a rubber stamp — say, with a broad red band across the center, — so that they may be readily noted when placed with cards containing names of those who are not customers.

87. In the vertical index file, in the folder under the customer's rotation number, in addition to copies of any correspondence, a form should be kept containing items of useful information that cannot conveniently be put on the cards. A note should also be made concerning any special applications of electricity at the consumer's premises, with any interesting data thereon. All information should be verified as far as possible by actually visiting the premises of the customer.

88. While it is advisable to get the above-mentioned particulars together as early as possible, it is, of course, very important to commence the actual soliciting, at the same time compiling a record similar to that mentioned above, of all buildings and their occupants, within reach of the existing service mains. To aid in getting this information together, maps of the distribution system should be prepared, with the various distributing mains indicated upon them in colors. This list completed, the remaining buildings in the city must be canvassed and listed in the same way. In both lists the form of illumination employed, with details as to the number of gas jets, Welsbach burners, average monthly or quarterly bills, and the name of the owner of the building, should be carefully noted. To aid in obtaining the occupants' names the local directory will afford considerable preliminary assistance, and the telephone book will form a useful check, but these cannot usually be fully relied upon, and it is most necessary to obtain exact records. Even such an apparently small item as getting a man's initials correctly, *and his name* spelled properly, is of more importance than *appears at first sight*, for many men are very sensitive on this

point, and to rub a man the wrong way, even in the slightest degree, when soliciting business is a mistake which should be carefully avoided. A correct and complete record is always of value, anything else is useless. Having obtained the record, it must continually be kept up to date by following up all removals which take place in the city, information concerning which should be sought from daily papers, from friendly real estate agents, auctioneers, architects, contractors, and from all others who are likely to know of such changes.

89. An information file should be kept in the office, for general reference, containing illustrations, data, and prices of special combined apparatus designed for operation with electricity, such as coffee grinders, milk shakers, air pumps for raising liquids, heating devices, etc. Such a file is very useful in assisting customers in the selection of labor-saving and, incidentally, energy-consuming devices, therefore a special effort should be made to keep it well abreast of the times. It should be classified according to the uses to which the apparatus can be put, basing the classification on some well-known standard system such as an extension of Dewey's, which is employed by nearly every public library in the United States. A card index should also be prepared for use in conjunction with the file collection.

90. The various **mechanical aids to new business getting** may be tabulated together with the details of their operation as below: —

Main Card Index

91. Arrangement: —

(*a*) In alphabetical and numerical order of streets.

(*b*) Streets indicated by guide cards with projections at the left-hand side.

(*c*) If the index is a big one in a large city, intersection of cross streets on a street should be indicated by guide card with projections at the right-hand side.

(*d*) North and south or east and west sides of streets should be indicated by another set of guide cards with projections a little way from one end.

(*e*) Where streets are long, more guide cards should be used to indicate the house numbers.

(*f*) Streets, or parts thereof, through which service wires are laid can be indicated by guide cards, colored on one side, the colored sides so faced or turned that the cards included between any pair of these faces bear the addresses of buildings in reach of present service mains.

Containing:

(1) In addition to occupant's name and address, the classification letters S, R, and P, and if a customer, his rotation number, also.

(2) Name of owner of building.

(3) Date of verification of the information.

Note: Cards must never be removed from main card index except temporarily for correction.

File Card Index

92. Arrangement:

Occupants' names in alphabetical order.

Containing:

In addition to the name and address, the number of the folder in the file containing all correspondence, data, and other records relating to that particular occupant.

Note: (*a*) Even if there is no correspondence, or other material to file, a card should be made out (without a folder number) for every address in the city. The index can then be used to locate a man whose name only is known.

(*b*) Cards must never be removed from this index except temporarily for correction.

Vertical or Other Files

93. Arrangement:

In numerical order of folder. The folder number for customers should be the same as the rotation number. A separate series of numbers should be utilized for other than customers, the number being changed on the folder and file card index for the rotation number, when the person concerned becomes a customer.

Containing:

All correspondence, agreements, estimates, etc., also all *technical data* and general information collected by *canvassers.*

Note: When any information is required, the whole folder should be taken out. On no account should anything be removed from a folder once it has been placed there; in this way much confusion can be avoided.

Address Plates of Addressing Machine (if such a Machine is Used)

94. Arrangement: In three main sections (S), stores and business premises; (R), residences; (P), places where power is used; each section being divided into six subsections.

Mark	Indicates that Addressee
1	Is not at present interested.
2	Partially interested in light, heat, and power.
2 (L)	Partially interested in light.
2 (H)	Partially interested in heat.
2 (P)	Partially interested in power.

Customers are indicated by their rotation number and respective section letter S, R, or P. Each section should, if possible, be contained in a separate case to obviate any danger of mixing.

Section Card Index

95. Arrangement: (*a*) The same as that of the address plates of the addressing machine.

(*b*) Clips or markers, bearing a number corresponding to the day of the month, can be attached to the cards referring to any occupants, whom it would be wise to look up on that particular date, or with whom an appointment has been made for a future date. Thus the index will serve as a constant reminder of these dates, and for that purpose should be examined every day.

Containing: (1) Address, as on address plate, with section and subsection mark.

(2) A dated record of the numbers of all form and circular letters sent out, also booklets and other advertising matter, *and dates of personal* calls.

Maps of Territory

96. Arrangement: Location of high-tension, service, and power lines, marked in different colors.

Information File

97. Concerns any electrically operated apparatus; data kept in classified folders.

Information File Card Index

98. Subjects in alphabetical order.

A book of the loose-leaf form should be provided with contents classified, containing notes on the general schedule decided upon and copies of standing instructions relating thereto. Duplicate copies of this book should be maintained — one for general use and the other for the manager's reference.

99. Only those who have applied the labor-saving business aid, known as **the card system**, to the commercial department of a central station, can realize how unwieldy and useless it is apt to become, unless carefully thought out. The basis of the schemes suggested here is that the main index be arranged in alphabetical and numerical order of the streets; this is done on the assumption that the buildings are the permanent features, and the tenants liable to change. This list covers the main requirements. For circularizing and other special purposes, it is necessary to distinguish between stores, residences, and factories, hence a corresponding classification and any needful subclassification are made of the address plates of the addressing machine, each set being still kept in alphabetical and numerical order of the streets. If an addressing machine is not employed, the main card index will serve as it is for copying addresses from, the classification mark decided upon being put very clearly on each card.

100. Some one has doctored up an old saying, and made it read thus, "A little system is a dangerous thing." This is also true of too much system. In organizing a new business or commercial sales department, the central station manager will do well not to forget that it is possible to become swamped with system if the thing is carried to extremes.

101. A good system should be devised for the business, and not the business turned upside down to fit any one particular system — no matter how highly recommended.

102. As the newspaper and mail advertising campaign (which it is assumed is in operation) will be bringing in **inquiries** before the solicitors have completed their preliminary systematic canvass of the territory, arrangements must be made for taking prompt and proper care of them; the solicitor from whose territory the inquiry emanates being advised to look it up as promptly as possible.

103. The solicitor in making out the **report of each call** should indicate whether the occupant was (1) not at present interested, (2) partially interested in (L) light, (H) heat, or (P) power. The object of this being to possess a record which shall form a guide as to the advertising literature that should be sent to arouse interest and carry it past the stage of partial interest. The remaining case, the interested party is, of course, at once taken care of, and, if possible, converted into a customer; if this cannot be done, he should be classed as "partially interested." As this information is obtained, the plates of the addressing machine — if the central station possesses such a machine, as it should do — should be sorted out accordingly. A card index, which is a duplicate of the address plates of the addressing machine, should be prepared and arranged in the same way, so that the three main sections, *i.e.* the S list (stores and business places), the R list (residences), and the P list (places where power is used) will now each have been divided into six subsections, indicated as below: —

Mark			Indicates that the Addressee
S list	R list	P list	
S (1)	R (1)	P (1)	Is not at present interested.
S (2)	R (2)	P (2)	Is partially interested in light, heat, and power.
S (2 L)	R (2 L)	P (2 L)	Is partially interested in light.
S (2 H)	R (2 H)	P (2 H)	Is partially interested in heat.
S (2 P)	R (2 P)	P (2 P)	Is partially interested in power.
S	*R*	*P*	Is a customer.

104. Loose-leaf **mains forms** (with heading as shown below) should be arranged in the solicitor's pocketbook so that he may know where the existing mains in his district run and also where extensions will be made if required, so that if a prospective customer wishes to know if he is within reach of the electric service, the solicitor can inform him immediately without having to refer to the office. These forms should be kept in alphabetical and numerical order of the streets, and carefully revised from time to time.

LOOSE-LEAF MAINS FORM

STREET	RUN OF MAINS		DATE	REMARKS
	FROM	TO		

105. It will be of considerable assistance if a local **street map** is cut up into sections, so as to fit the solicitor's pocketbook; the run of the mains being marked on each section in colored ink. The date of the last correction should be indicated on each section to insure that it is in accordance with all the latest extensions.

106. If this plan is adopted, there will be no need to use the loose-leaf mains forms, previously referred to.

Avenue Road	No.	Class
Name		
Shop Residence Power User		Uses Electricity for
Now Using Electricity Gas Oil		Sign
Quarterly Gas Bills Mar. June Sept. Dec.		Flatiron
Building wired for Lighting Outlets Heating		Hot Plate
Outlets		Kettle
Interested in Electric Light Heat Power		Radiator
		Fan
		Motor
Owner of Building		
Owner's Address		

CALLS MADE

Date	Remarks	Initials

A form for a card index record of all tenants of houses and other buildings along the route of the mains. These cards are to be filed alphabetically according to the street names, or numerically according to the street numbers, the cards for each street being placed in the same order as the numbers of the houses.

BLANK FORM FOR DATA CONCERNING THE LIGHTING BILLS OF LOCAL CONSUMERS

NAME	ADDRESS	TOTAL BILLS PER ANNUM	TOTAL KW.-HRS.	NO. OF 50-WATT EQUIVALENTS	PER 50-WATT EQUIVALENT	
					Cost	Kw-hr.

THE RELATION OF THE COMPANY TO THE CONSUMER

107. The relation of the company to the consumer is the same as that of any producer to those who use his products. It is essential that this relationship be very close and friendly. In the eyes of the consumer, the solicitor represents the company, hence his prime duty is to maintain pleasant relations with both present and prospective consumers.

108. *The solicitor* has also to bear in mind the impor-

[illegible] **attending** promptly to any **complaints** his [illegible] may have to make; in short, he must make it [illegible] every one that his company is ready to do all in its pow[illegible] the convenience of consumers.

109 Hence the necessity for giving careful atten[illegible] such **customers** as have already been **secured**. The solic[illegible] efforts to obtain new customers will not be of much av[illegible] the men to whom he speaks have in mind a store or hou[illegible] which electricity does not seem to be a success. For alth[illegible] this seeming failure is due, not to electricity, but to the ca[illegible] ing out of the "penny wise, pound foolish" system of bu[illegible] insufficient lamps because they are cheap, or of continui[illegible] use good lamps after they are really worn out, bad arra[illegible] ment of lamps, etc., yet to the uninitiated, naturally electr[illegible] has to bear the blame. Therefore the importance of pa[illegible] attention to existing consumers, both warning them o[illegible] false economy of such procedures, and also giving [illegible] advice as to how they may arrange their lamps in ord[illegible] secure the best possible light at the lowest possible exp[illegible] [illegible]. Each satisfied customer is an added advertiser, while all who are not perfectly pleased with the service d[illegible] [illegible] by their dissatisfaction even if they do not act [illegible] [illegible] other means of lighting.

110 [illegible] the importan[illegible] **[illegible] the customer** [illegible] concluded [illegible]

111 [illegible] **business dealing** [illegible]

licitor who gives way. Therefore it behooves the solicitor be business-like; he must not cut his figures, but quote r prices in the first instance, the same prices and terms at he quotes every one else under similar conditions.

112. Anything that can be arranged by the central station **reduce the initial investment of house wiring** should be one. If the central station does not carry out house wiring, e local contractors should be supervised, to see that their rk is done in the best and most economical way; that is, e central station should be prepared to act the part of a nsultant, to advise upon a suitable installation and draw a specification, and to arrange to inspect the work as it oceeds. The majority of wiring contractors consider at all they are called upon to do is to pass the insulation st required by the electrical authority, and that the smallest e wire or cable that will carry the current demanded thout getting dangerously heated can be employed; at e same time they will often play upon the ignorance of a stomer with respect to his fear of possible fire risk, per-ading him needlessly to install, say, an expensive main itch or other device. Any tendency on the part of the ntractors to talk of electrical fire risks must be imme-ately suppressed, as it is apt to do a great deal of damage central station business.

113. Local conditions and environment have a great deal do with the suitability of the application of any special opositions, and they must be borne in mind when con-lering the following notes.

114. Usually the most difficult case to deal with is that **the man who rents**, and does not own or lease the house is in, for he does not feel **justified in wiring**, not knowing w long he will stay there, and his landlord often will not re unless he can obtain an increased rent which is out of oportion to the enhanced value of the house due to the stallation. As more and more houses in a town become red, the landlords find that they have increased difficulty letting the unwired houses; it is not, however, easy to ake them see the advantage of wiring their property, until ey are compelled to do so in order to let the house at all. the landlord is obdurate, it is often advisable for the cen-l station to get permission from him to install wiring in

the house for a term of years and make arrangements with the tenant to purchase his own fixtures, and to pay a fixed sum monthly in addition to the charge for energy consumed; this fixed sum being based on the interest and depreciation on the investment. As it is divided into monthly installments the amount to be paid does not appear large, and the probabilities are that if a tenant should leave, the incoming one would also use the light. There are, of course, risks in undertaking work on this basis, but it is all helping towards the attainment of the day when it may be said that practically all the houses in the city are wired.

115. Arrangements should be made, if the central station does not find it expedient to do the work itself, whereby all the arc lamps in the city should be trimmed by one contractor under a special agreement, made, say, on a yearly basis, so that the actual cost of trimming to the consumer be reduced as much as possible; that is to say, that the central station should act as an intermediary between the contractor and the consumer, insuring a more satisfactory arrangement for both parties. This suggestion of arranging for the trimming to be done by one contractor is made upon the assumption that bids for the work, say, for one year, be received from any contractors interested and the most favorable accepted. If all the lamp trimming required in a city be in the hands of one firm, they can do the work systematically at a lower price than could be done were each storekeeper to make an individual arrangement.

HELPFUL HINTS TO STIMULATE ENTHUSIASM[1]

116. Drive One Point Home. — The average central station solicitor is apt to take too much for granted.

He, of course, knows his subject by heart and has a rippling lingo which drips from his silver tongue with the regularity of machine work — often it savors too much of machine work.

Remember that, while you should not treat your prospect as if he were an emerald numskull, bear in mind that he doesn't know as much about your proposition as you do.

[1] "The Booster."

You should enter into the details of your subject, laying due stress on the salient features, so that the prospective customer may grasp the situation with clearness and understanding.

If you fail to keep this in mind, the tendency is for you to ramble through your discourse hurriedly and superficially, in such a manner that your man will fail to follow you.

The safest way is to assume that your man knows about your proposition only as he manifests his knowledge.

If you hop, skip, and jump from point to point so swiftly that your man cannot digest what you say, you will find that instead of interrupting you for elucidation (and thus acknowledging his dullness) he will perfunctorily nod assent to all you have to say, and appear to comprehend, although when you are through, you will discover that you have not convinced him.

Not all men are quick, and but few men will acknowledge that they are not.

117. Planning Ahead. — Get out of bed in the morning and take a cold water plunge.

It's good for you and good for your company — wipes the cobwebs from your brain.

Go at your work afresh.

Spend a few moments getting your day's work mapped out.

Have it all methodically arranged — then fire ahead.

Your first call is on Jones.

You know Jones.

You know his business — or you should.

You know what kind of goods he sells — what kind of people buy his wares.

Figure out his needs.

Decide what will most benefit him.

Then sail into him on that subject.

Show him where he should have "that sign."

Tell him it will work when he and his helpers are resting their weary limbs for the business it will bring him on the morrow.

Every prospective customer is ready with a "no," get him to say "yes."

To sell electric energy intelligently, make yourself familiar *with the other forms* of lighting, heating, and power.

Keep track of gas explosions.

Keep track of asphyxiation cases.

Keep track of oil-lamp explosions.

The nearer the accident is to your territory, the better an argument it should be in your hands.

Carry newspaper clippings of these if possible. They'll help you to "show."

Intelligent conversation on topics of the day may help you with your customer.

Read the paper and keep posted.

Use tact.

Be resourceful.

Adopt a creed of persistent hard work.

Equip yourself with unwavering courage.

118. Get in the Game Right. — Solicitors are made, not born.

Don't get any misleading idea into your head that you'll never make a solicitor.

Be sure on this point: more sales are made as the result of "perspiration" than "inspiration."

You can't get away from the fact.

And the man who keeps everlastingly at it — never quits — who'll never say die — is bound to win in the end.

Introduce some of that bulldoggedness into your daily work.

Exercise your will power.

119. Remember the Little Fellows. — Too many central station solicitors are content to touch only the high places in their canvass of a territory.

They want to grab off the big users, and when they have received a few contracts from some of these and turn-downs from the balance, they look upon their labor as done and demand a new territory because they say that "we have got all there is to get," forgetting that it is the small fellow's business that is going to grow into big business later, and that the central station can better afford and should in all reason prefer to have ten customers whose yearly revenue to the company was only $250 apiece, rather than one customer whose revenue to the company was $2500.

It is little fellows that count big, because there are so many *more of them.*

SECTION 2

TALKING POINTS

SECTION 2

TALKING POINTS

INTRODUCTION

1. No attempt is made to give here a complete list of talking points, but rather to give the **fundamental facts** upon which practically all are based, and illustrations to show how the facts can be adapted to various conditions and presented to the prospective customer in a way to convince him of the superiority of electrical energy over all other forms as applied to his particular case.

2. Before going any farther, it maybe well to say a word as to the **nature of electricity** itself. As was pointed out in Section **1**, what people want is light, heat, or power, and they do not care how they get it so long as the results are satisfactory and the cost low. Light, heat, or work done by a motor are all derived from energy, and this must be purchased in some form or other. Energy is stored in coal and gas in chemical form, and can be extracted therefrom only by combustion. Electricity is similar to gas in that it can be considered as a medium transmitting energy from one place to another, but unlike gas there are a great many different ways in which electrical energy can be utilized.

3. It can be completely transformed into heat, without any loss, it can be made to exert a mechanical pull with but slight loss, as exemplified in magnets, motors, etc., and it can produce light with but slight heating effect.

4. The **fundamental advantages** of electricity are: Safety, health, purity, adaptability, control, and economy.

5. **Safety** is the first requirement of any agent used to transmit energy. Dynamite has an enormous capacity for storing energy, and were it safe, would undoubtedly be used to drive internal combustion engines instead of gas.

6. *Next to safety* from sudden death and dangerous acci-

dents comes **health**. That illuminant or energy carrying medium that requires the least oxygen in its utilization is undoubtedly the most healthful — electricity requires none. It does not contaminate the air in the least and can be adapted to every conceivable form of illumination without the slightest danger of fire, so that the best results from a hygienic standpoint are easily obtainable.

7. Assurance that **the energy paid for is being delivered** is a great satisfaction to the customer. Electricity cannot be adulterated, and the meter measures energy and not electricity. The light, heat, or power depends on the energy, and the energy is equal to the quantity of electricity times the voltage. Now if the voltage is not kept up, the light will be dimmer and the motors will run a little slower, but the meter will also run slower, so that if good service is not given, neither is it paid for, thus the meter automatically protects the customer.

8. The **adaptability** to practical service conditions is often considered before the cost. Electrical energy is far ahead of all other forms when it comes to adaptability, which is unlimited. New ways of applying it are invented every day. Electric lighting can be adapted to suit any imaginable architectural scheme without entailing the slightest fire risk.

9. Electric motors can be applied to all commercial machines and appliances where power is needed in any desired quantity and at any desired speed.

10. Electric heating is costly when compared with gas or coal on the energy basis, but when adaptability is considered it has the field all to itself. The heat can be applied just where it is wanted and in any desired degree.

11. **Control** of the energy so as to get just the proper effect is a very necessary feature in many cases. Electrical energy is always under perfect control. Light, power, and heat can be regulated at will by pressing a button or turning a knob.

12. Last but not least is **economy**. A volume could be written on this one talking point, there are so many ways in which it can be presented. The economy is mainly in dollars for unit work satisfactorily accomplished. It is not always a question of the cost of energy supplied, but more *often the efficiency* of its transformation into useful work.

13. Owing to the ease with which electricity can be turned on and off, waste can be avoided. Aside from this, electrical energy can be more completely utilized either as heat or light than can any other form. By using efficient apparatus in a judicious way, the electricity bill for a given service can be made so low that it can stand comparison with that for any other form of energy.

14. The electric motor is very efficient throughout its operation both above and below normal speed, and is therefore excellently adapted to fluctuating loads and low load factors.

ELECTRIC LIGHTING

22. The **advantages of electric lighting** are many. It is safe, hygienic, adaptable to all sorts of conditions, perfectly controllable and very economical. No other illuminant can be used in as many different kinds of lamps.

23. Electric lamps are made in all shapes and sizes, from tiny globes to long tubes, and the quality of light obtainable with them depends on the type of lamp. The color of the light differs widely in the various types, as well as the brilliancy and intensity. A considerable range of tints can be secured in the flaming arc and the Moore tube, to suit the purposes to which they may be devoted. The intensity of light varies from a fraction of one candle power in the miniature incandescent lamp, to many thousand candle power in the multiple arc; the brilliancy varies from that of the arc — the most brilliant artificial light known — to the mercury vapor and Moore tube, which give such a diffused light that practically no shadows are cast. The different types of lamps are described in Section 3.

24. In the following paragraphs the advantages of electricity as an illuminant will be discussed under specific headings.

25. Safety. — Electricity as employed in the central station at high pressure is, of course, dangerous, just as high pressure steam is dangerous. But electricity at the pressure used for house lighting is quite safe. The worst that could happen to any one touching live wires in a private house would be a somewhat unpleasant tingling sensation, like pins and needles. There cannot be anything very serious about it, since wiremen habitually test whether a circuit is

alive or not by putting their bare fingers across the exposed parts of the wires under the switch covers. There is, of course, no necessity or probability that the householder will ever come across two bare wires, as they are all well covered, but even if he should there would be no danger. As far as danger to children is concerned, the electric wires are always placed far out of their reach.

26. If the wiring should be mechanically damaged, a safety device, known as a fuse, cuts off that portion of the wiring system. As no matches are required to light up, accidents due to loose matches and unextinguished match ends are avoided.

27. When any one gets a shock in an ordinary house, it is generally due to his attempting to effect repairs with the switch in. It is much wiser to leave repairs to the experienced workman.

28. In regard to **fire risk**, the prevalent notion that electricity is responsible for a certain number of fires is largely the result of newspaper imagination, evidenced in such a remark as this: "The fire was believed to have been due to the fusing of an electric wire." Every one knows that imagination is an exceedingly well-developed feature in the newspaper man. But to turn from generalities to facts, for facts are stubborn things, the London County fire brigade committee in their report of the causes of the 3400 fires which occurred during the year, speak of none as being caused by electricity in any form. The Phœnix Fire Insurance Company says: "The electric light in the opinion of the Phœnix Fire Office is the safest artificial illuminant in existence and is preferable to any other." Other insurance companies say: "The fires reported as having an electrical origin . . . were a very small proportion of the total fires from all causes." The Fine Art and General Insurance Company says: "We beg to advise that we are always prepared to consider the question of discounts for electric lighting, and have little doubt that we can make concessions to any intending insurers and users of electricity."

29. In the very early days of electrical practice lack of knowledge and experience did result in defective installations, but all that is long since past, and he must indeed be slow-going who gives any credence to-day to the newspaper man's *favorite cause* of fire outbreak.

30. In New York the **fire losses** from 1902 to 1905 inclusive which were traceable to defective wiring or other electrical causes, were only 361 cases with a total loss of less than $250,000. The electrically caused fires were only 1.34 per cent of the whole, and the losses 1.15 per cent of the whole. The population of New York is about 4,000,000.

31. If, therefore, the public desires to be freed from the constant fires which are such a menace to general safety, obviously the use of electricity for lighting purposes will commend itself. When electricity comes into its own, there will be no need of chimneys.

32. It does not require a very great enthusiast to prophesy that the time will undoubtedly soon arrive when about 75 per cent of the buildings in every city will be wired for some application or other of electrical energy.

33. Health. — Prospective customers will always admit that electricity is the illuminant that is best so far as the question of health and comfort is concerned, but they do not always appreciate the great difference between artificial illuminants. An interesting quotation from the building laws of a large city follows: —

"Every hall, auditorium, or room of every building hereafter erected for or converted to use as a schoolhouse, factory, theater, or place of public assembly or entertainment, shall have in continuous operation while occupied, a system of ventilation so contrived as to provide 25 cubic feet per minute of outer air for each occupant and for each lamp other than electric."

34. Comparative Vitiation of Air by Electricity, Gas, and Candles (See **35**).

Source	Consumption	Heat Units per Hour	Lb. Carbon Dioxide per Hour	Approx. Candle Power
1 arc (5 amp. d. c. or 7.5 amp. a. c.)	550 watts	2,100	0.002	750
11 16-c. p. inc.	550 watts	2,100	0	176
5 50-c. p. meridian	525 watts	2,000	0	250
10 5-ft. gas	50 cu. ft.	35,000	3.4	200
200 wax candles	3½ lb.	70,000	10.7	200
50 adults	——	6,500	3.4	——

35. In the table the figures for electricity are based on what the company provides; the figures for gas are based on 20-c. p. gas when used in a flat burner (the New York State Gas Commission reported an average of only 19.11 for gas in its last report), giving 700 B. t. u. per cubic foot, the vitiation of air being taken from figures given in the Encyclopædia Britannica; the figures for candles are based on the standard of 120 grains of wax per candlepower-hour; and the figures for the heat produced per person are rough estimates made by an expert.

36. Assuming that each worker needs one electric lamp, it will cost not over five cents per day at most, and often only two cents or one cent a day. If the wages are paid at the rate of $1 per day, the increased health and comfort of the worker, due to better light and ventilation, should mean at least 10 per cent more work or better work, which would pay more than twice the cost of the electric energy.

SPECIFIC ADVANTAGES OF ELECTRIC LIGHT

43. Residences. — Electric light is turned on with a touch; can be placed in any position, and therefore is especially suitable for decorative purposes. It is absolutely clean and free from odors. Does not exhaust the oxygen in the air of rooms where it is used. Turn-down lamps can be used in nurseries, sick rooms, and bedrooms without danger of foul gases being generated. Electric light is steady. Shades of color can be distinguished more correctly by it than by any other artificial illuminant. It does not injure fabrics, blacken ceilings, rot leather, ruin the polish of furniture, or spoil wall paper. There is no waste, as with other illuminants, as electric lamps can always be turned off when not needed, and are easily lighted again, with no search or fumbling for matches. All lamps in the house or on the grounds can be turned on with a touch, at any instant during the night, thus offering a most effective means of foiling thieves or burglars. This can be done by a switch at the bed of the owner, or by an automatic burglar alarm.

44. Stores in General. — The great advantages of electric light from the storekeeper's point of view are: —

1. That it does not soil or damage his stock.
2. Does not produce unnecessarily high temperature, thus causing his stock to deteriorate.
3. Permits the use of the upper shelves for all classes of goods.
4. Allows of the use of dust-tight, and at the same time well-illuminated show cases and windows.
5. Shows up goods in their natural colors.
6. Does not sap the strength of the clerks, who are consequently more energetic.
7. Is an excellent advertisement and a guarantee of the high quality of the goods sold.

45. Bakeries. — In the case of the baker it might be thought that B and C could never come together (baker and coolness), but with the bakehouse relieved through electric light from the hot, close atmosphere, and if equipped with an electric motor to drive the machine for mixing dough, and a fan at his oven to carry away the heat, then even a baker may hope to keep cool, and that in more senses than one.

46. Meat Markets. — To the butcher coolness of atmosphere is even more of a necessity than it is to the baker, and the reasons for this are not difficult to find. Meat is one of the most perishable of edibles, and heat, sooner than anything else, will render it uneatable. Electric lamps heat the air but slightly, and cool air means that —

1. Meat will keep fresh longer and will not lose flavor.
2. More meat can therefore be displayed in the shop.
3. Less ice will be required.
4. No risk of frozen meat being thawed or discolored.
5. The fat on the meat will not be melted.

Moreover, electric light throws just the right color on the meat.

47. Chemical Laboratories. — The chemist dreads excessive heat and varying temperature, because —

1. Sirups will ferment.
2. Acids will crystallize.
3. There will be difficulty with blown-out stoppers from the bottles containing volatile spirits.

4. Spirits of ammonia, chloroform, spirits of ether, etc., cannot be properly kept in a varying temperature.

48. Candy Stores. — Electric light is valuable here because it reveals the true color of the candy, also because it does not make the candy sticky by surrounding it with hot air.

49. Dairies. — Electricity is perhaps more essential to a dairy than any other place. The matter of providing young children with pure milk is of paramount importance, and the purity of the milk will be more likely to be preserved in an establishment where the air is not heated, contaminated, and defiled by the illuminant used. Moreover, a dairy should always have the appearance of scrupulous cleanliness and the entire absence of any dust or dirt, which can only be accomplished with incandescent lighting.

50. Dry-goods Stores. — It is vital for the store keeper to keep his goods in prime condition. If he uses electric light, his light-colored goods will not be soiled or the black tones become rusty. Upper shelves can be used for stocking material. Customers can match tints accurately, and do not cause inconvenience, therefore, by wanting goods changed that were purchased under misapprehension of their true tint. The staff of assistants will be more ambitious than when their strength is being sapped by breathing the fumes of gas. Last, but not least, the risk of fire from goods coming in contact with flame is eliminated.

51. Flower Stores. — No one can pass a florist's window that is skillfully lighted by electric lamps. The effect is fairylike, and electric light does not harm any kind of plant or flower, even the most delicate ferns being unaffected by it, and therefore the stock remains fresh looking very much longer. The mercury vapor lamp produces some most beautiful effects when used to illuminate green foliage.

52. Fruit Stores and Green Groceries. — Where electric light is used the fruit remains sound much longer, and the freshness of green stuff is unimpaired. Green fruit ripens gradually without blackening, and all the stock looks inviting under electric light.

53. Groceries and Provision Stores. — A pure atmosphere preserves provisions in a perfectly sound condition and prevents serious losses from the fermenting of jams and canned goods when a grocer or provision merchant has installed electric lamps. Moist sugars, dried fruits, cheeses, and soaps do not lose their weight because of overheating. Bacon never sweats and becomes discolored. With electric light provisions can be stored at any height without risk of deterioration. The wrappers of proprietary goods keep clean and fresh in appearance. The whole store is sweeter and cleaner.

54. Haberdasheries. — The haberdasher who uses electric light finds that the colored goods are unsoiled, while white shirts and collars do not become yellow, and the rubber in suspenders does not " perish " so quickly.

55. Jewelry Stores. — The jeweler who introduces electric light has to admit that never before has he had such an effective display. Much time is saved by not having to clean tarnish from the goods. Electric light shows precious stones off to the best advantage.

56. Music Stores. — Those engaged in this trade do not have to repolish their new pianos or lose sheet music on account of discoloration, if electric light is used.

57. Saloons. — The temperature is kept low and the atmosphere fresh, while the often elaborate decorations do not tarnish.

58. Shoe Stores. — By installing electric light stock may be kept on the upper shelves; elastic sides will not lose their spring, and the leather in boots will not get hard and stiff if stocked for some time, while the thinner and softer kinds of leather from which ladies' French kid shoes are made will not crack.

59. Stationery Stores. — With electric light there will be no discoloration of note papers or spoiling of fancy articles from heat and dirt.

60. Tailor Shops. — Too much heat makes every kind of cloth harsh and dry. If electric light is used, this is avoided and all woolen goods are kept perfectly salable. Air-tight and dust-proof cases and windows are possible, as electric light requires no oxygen.

61. Upholstery and Furniture Stores. — If electric light is

installed, the furniture does not need constant repolishing, nor does the wood crack and warp; upholstery draperies remain unfaded and fresh; oil-polished furniture does not sweat.

62. Hospitals and Operating Rooms. — There are many ways in which light can be employed to advantage in the medical world. Electric light is the coolest and most sanitary method of lighting sickrooms and hospitals, and it is the best substitute for daylight if an operation has to be performed at night.

In dental surgery a good steady light is of the utmost importance. Electric lamps for use in medical practice, such as the throat lamp, the laryngoscope, the gastroscope, and other special lamps, are of great service to physicians.

There are also the tubes used in the production of Röntgen rays for radiography, the electric light bath, the lamps for producing the necessary rays for the Finsen treatment. In these and many other ways electric light is of great value to doctors and surgeons.

ELECTRIC LIGHT ADVERTISING

63. Effectiveness. — By actual figures it can be shown to a dealer that, space, effectiveness, and circulation considered, an electric sign and a well-lighted show window form the cheapest as well as the best advertising means he can employ. As a mode of advertising it can be compared with the newspaper, and his attention can be drawn to the fact that it is much more valuable, more people see it, that it is more attractive, more economical than maintaining an advertisement in a newspaper, and that the actual cost of one evening's illumination is less than that of a reasonable space in a local paper. These arguments can, of course, be presented in such a way that the newspaper is not deprecated as a means of advertising, or the withdrawal or discontinuance of newspaper advertising advocated, while at the same time the value of an electric sign can be impressed upon a man by showing him how it acquaints people far and wide with his name and the location of his business.

64. Advertising by Store Windows. — The object of a store window is to advertise not only by day but also at

:. It is to be feared that the advertising benefits of many windows are lost when darkness comes. This is not as ›uld be, for the hours after dark are the most valuable e whole day for advertising purposes. A store window ciently lighted is like a harp without strings.

. The lighting of store windows is not primarily a tion of expense, but of efficiency. Even for the same nditure a better effect can be obtained with electric than with gas because electric lamps can be so skillfully ed as to throw the light in the right direction, and placed actly the right spot without fear of the goods catching ›r of being spoiled with heat. As to the main question ficiency, electricity is far superior to gas, since for the tive display of goods more light is necessary than any installation can give. With electric light there is no , practically, to the amount of illumination that can be ed, as electric light lends itself to concealed illumination, corresponding increase of light without an overpowering .

. The **ideal store window** first attracts the attention of rs-by and then holds it. At night both objects are at- d by the efficiency of the illumination.

. First, as to the **attraction of attention**, the window be brilliantly lighted so that from some distance it is a picuous spot. Many people will specially cross a street e what is displayed in a particularly bright window. tant variety can be obtained without trouble owing to the ›le connections of the lamps. A window well lighted by ricity is so charming in its effects that it cannot but leave ›st favorable impression upon those who look at it, and be classed therefore in the list of advertising methods. e is no reason why all the pulling in this direction should lone by saloon keepers, who almost invariably have ıtly illuminated windows.

. A store window should not only be brightly lighted, cept so as long after business hours as the streets are full eople. The majority of stores depend on the working es for the bulk of their custom, and there are many of whose only chance for observing window displays is closing hours. The streets are filled with persons at this *of the day either* going home or to some place of amuse-

ment, and it is a golden opportunity for displaying wares, while the neighbor's window may be dark and unattractive. It is the actual record of experience of those who have adopted this method that customers will come the next day inquiring for goods that they have seen in the windows the night before. An automatic switch can be arranged to turn off the lamps at any hour desired.

69. Then as to **holding attention**. It is not enough to draw prospective customers to the window, but the effect on closer view must be such as to induce them to remain and look at the display. The lamps should be concealed from view by shades so that the light does not try the eyes. With electric light the goods will look fresh in every detail, and their colors will be shown to advantage. The decorations of a window so lighted remain clean and untarnished for years, there being no destructive fumes as from gas. Dust and dirt can be excluded by the practicability of making the window air-tight — an impossibility when using gas or oil lamps. The glass of the window remains clear and undimmed by condensation of moisture, as electric light does not give off vapor or cause fluctuations of temperature.

70. **Advertising by Electric Signs.** — Electric signs are now regarded as among the most profitable advertising mediums. Within the last two or three years much ingenuity and art have been exercised in improving the designs and heightening the effect of these fixtures. New York, Paris, Berlin, Brussels, and even London have had a new night aspect imparted to some of their principal streets. Broadway and the Boulevard des Capucines simply burst into flower after dark, for thousands have been spent on these two streets alone for electrically illuminated devices of all kinds.

71. There are nearly a hundred thousand of these signs in the United States. It is not to be supposed that shrewd money making merchants would use electric light if it did not bring in business. They are not using it simply to help out the central stations, but to make money for themselves.

72. Some people will read the advertisements in the newspapers, but no one can help reading an illuminated sign. *Figure its effectiveness as being in proportion to the population of the city* where it is placed.

ELECTRIC HEATING

73. The salesman of electric cooking and heating apparatus who enters the field at present may justly be considered as a **pioneer**, and, compared with older lines of industry, he is working virgin soil. He is offering for sale something about which the public is almost wholly ignorant, and the use of which by the individual is, in the majority of cases, experimental; the first cost is apparently excessive, and the expense of operation, owing to a widespread impression, seems exorbitant. He must be able to convince the prospective buyer that the efficiency and practicability of electric heating are assured; that the first cost of the apparatus is not excessive when its durability is considered; that the scientific knowledge necessary to its proper construction, as well as the time, money, and labor that have been expended to bring it to its present perfected form must be taken into account; and that the expense of operation need not be exorbitant.

74. The electric system of heating is notable for—

1. The sanitary conditions its use promotes;
2. The cleanliness it maintains;
3. The convenience and flexibility which it offers;
4. The reasonable expenditure it entails;
5. The safety it insures.

75. In **cleanliness, convenience, and safety**, electric cooking and heating apparatus has no rival.

76. A steak broiled on an **electric gridiron** has a flavor and juiciness entirely unique. No other method of cooking can show equal results.

77. When the baby cries at night, turn the switch on the **milk warmer** placed by your bed. In three minutes reach out for the bottle, give it to the babe, and go to sleep again.

78. The **consumption of coal** in a coal stove continues after useful operation is completed. There is no necessity for consumption of energy with electric heating apparatus after the work is done.

79. Electric heaters of all kinds will continue to do efficient work for fifteen or twenty minutes after the current is turned off.

80. Loss of energy and useful heat by **radiation** from a coal or gas stove is very great. This is practically eliminated

when electric heating apparatus is employed, the heat is applied exactly where needed, and none is lost through radiation.

81. There are two distinct **kinds of heating** required in practice; viz. radiated heat for warming large air spaces, and localized heat such as is used in cooking and various industrial processes. In the former field electric heating is not strong because of the large amount of energy necessary. Electric energy being in most cases derived from coal, it is generally cheaper to apply the heat of the coal directly. When heat is required intermittently, however, as in the spring and autumn, it is often cheaper to use electrical radiators than to start the house-heating system.

82 From a **sanitary point of view electric heating** is all that can be desired. An electric radiator uses up none of the oxygen in the air, nor does it vitiate it in any way. It absorbs little or no moisture, as there are no intensely hot surfaces to come in contact with the air. Neither does it give off unhealthy fumes of any sort. This is one reason why it is such an invaluable means of heating a nursery, for it does away with that fruitful source of bronchitis, — the sulphur fumes from coal fires.

83 The perfect **cleanliness** which characterizes the **electric radiator** is also a great argument in its favor. There are no smuts to fly about the room and lodge upon every available spot, and there is no danger of a smoky chimney bringing discomfort or dirt into the house.

84 **Conveniences** secured by the use of the **electric radiator** are many. It is small, it is portable, it is quickly available, it requires no matches, and it is controlled by a [illegible]. For use in a summer cottage on [illegible] a very great comfort where no [illegible]. In bedroom or bath- [illegible] fires are started it [illegible] autumn days.

85 [illegible] an electric radiator [illegible] when the advan- [illegible]. There are some [illegible] because of the benefits [illegible] of the electric [illegible] actually uses.

86. Lastly, but by no means least, the **electric radiator** has a powerful claim for consideration as a means of heating because of its immunity from **fire risks**, and from the danger of injury to rugs and carpets, such as are often incurred by sparks from an open fire.

87. When it comes to **localized heat** there is no method which can even be compared with the electric method. The heat can be generated just where it is wanted, the rate of generation and the quantity of heat being under perfect control. **Electric cooking** offers, perhaps, the widest field for localized electric heat.

88. Instead of sending a goodly proportion of the heat up the chimney or into the room, while the remainder does what it can to heat the cooking utensil, all the heat is concentrated in the place where it is wanted, leaving the surrounding atmosphere as cool as though no cooking were being done. The fundamental principle of electric cooking is that the heat is where it is wanted and nowhere else. This, however, is not the only advantage to which electricity as a means of cooking can lay claim, and it will perhaps be well to tabulate some of the **good points**.

1. No heat is wasted by going up a flue or passing into the air around the apparatus.
2. Directly the heat is no longer needed the current can be turned off, and again no waste occurs.
3. Heat can be obtained at a moment's notice — no waiting for a fire to burn up.
4. The cooking apparatus is portable and can be moved from one room to another as is convenient.
5. Therefore, also, there is no need for stooping, as the electric oven can be placed upon the table or at any convenient height.
6. No dirt to accumulate on cooking utensils on account of combustion of by-products, and therefore washing up is not such a disagreeable process.
7. The heat can be regulated to a nicety.
8. Economy in time and fuel.
9. No bad odors, foul gases, or fumes generated.
10. No danger of fire or explosion.
11. No flame to be blown out by the wind, and no danger, *therefore, from "back* draught." The breeze can be freely

admitted to the kitchen in summer, as would be impossible in case of gasoline fuel.

89. In these days, when it is so increasingly difficult to obtain good servants, such a list as the above cannot be read without great interest. The vagaries of the species "help" can be regarded with more indifference by the mistress of the home if she knows that she herself is rendered independent by the possession of that powerful ally, — electricity, — which does away with the most disagreeable and dirtiest part of housework.

90. **Electric Cooking Apparatus.** — As regards the special adaptations of electricity to the work of cooking, attention must be drawn to the following: —

1. The electric coffee percolator is an ornamental as well as useful adjunct, which can be placed on the table, and delicious coffee will make itself therein.
2. The electric hot plate, which is also for the breakfast table, to keep a kettle or special dishes warm. No more trouble about keeping a delayed dinner hot.
3. The electric chafing dish for making little dainties for breakfast or supper without unnecessary exit to the kitchen.
4. The electric tea kettle, for use at afternoon tea.
5. The electric grid for making biscuits, griddle cakes, or toast.
6. The electric frying pan.
7. The electric oven.
8. The electric egg boiler.
9. The electric water heater and cereal cooker.

91. **Lack of variety** in the menu should not be complained of where electric cooking appliances such as these can be used, for all the work involved lies in the preparation of the ingredients for cooking. The dusty, dirty work of starting a coal fire is rendered unnecessary in the house where electric cooking apparatus is installed. Heat is immediately supplied upon demand, and is regulated by simply turning a switch instead of piling on coal, opening and closing dampers, etc. By means of wires which convey the current directly beneath the cooking utensil a steady, even heat can be maintained, the switch enabling the cook to vary the degree of temperature at will. There is no visible evidence of heat — *no flame or light,* but the warmth can be felt gradually in-

creasing after the switch is turned on. No complicated performance is necessary to obtain electric heat, and a servant ought to manage it well enough. Electric wires connecting the cooking utensil with the floor or wall plug are quickly and easily placed in position, the switch closed, and at once the heating begins. If any mistake should be made, such as turning the switch on before the wires are connected, no serious mishap will occur, and no danger is possible with the low voltages supplied in private houses. Of course if the current is turned on beneath an empty saucepan or kettle, it will be damaged, as would happen over any fire.

92. Compare this mode of obtaining heat with the old-fashioned one of chopping kindlings, fetching in coal, clearing out ashes from the grate, cleaning the flues, finding matches, laying the fire and waiting for it to burn up, not only waiting for it, but waiting on it all day long. Obviously much time is saved by the electric method of obtaining heat, and considerable money is also saved which might have been spent for coal and kindlings.

93. **But what advantages has the electric cooker over the gas cooker**, which, if matches happen to be handy, is also quickly lighted up ready for use? It has many. For instance, in the gas cooker it will be necessary to watch carefully when the gas is turned low to see that it does not go out. A sudden draught may extinguish it, or the burner may get stopped up. None of these difficulties exist to be guarded against with the electric cooker. Moreover, though gas cookers are certainly cleaner than coal ranges, yet they are far exceeded by electric cookers in cleanliness. Burning of gas results in the formation of carbon which is deposited on the bottoms of cooking utensils, making them dirty, and as carbon is a non-conductor of heat, utensils so coated lose much of their usefulness. With electricity no carbon deposit is formed, and all electric cooking utensils remain perfectly clean on the outside, thus making less trouble for the housewife, as carbon deposit is very difficult to remove.

94. Another reason why electricity surpasses gas for convenience in cooking is that all **apparatus** is so **easily portable**. It can be set up in any room where there is a lamp socket, and is *especially adapted* to being moved from one room to another.

In a gas range the component parts for broiling, frying, boiling, toasting, and baking are made into one stove, and the result is that the whole is too cumbersome to be moved about readily. Now this is not the case with the electric cooking devices; the hot plate, chafing dish, hot-water heater, frying pan, oven, etc., are all independent of one another and can be used separately or all together. Therefore it is easy to carry them to the room where they are wanted, and the lady of the house can preside over the concoction of delicate dishes in her dining room instead of being exiled to the kitchen to superintend the operations of the cook. Even the baneful words "I leaves this day month, mum," are listened to with greater equanimity if the mistress knows she has at her disposal the services of electricity.

95. One of the special features of cooking by electricity is the **uniformity of temperature** that can be maintained. The heat is not greater in the oven one day than on another, and so with each of the electric cooking appliances. With this favorable characteristic the science of cooking by electricity can be conducted with mathematical precision. The length of time it takes a certain dish to cook once known, that dish can be tested as to being sufficiently cooked by looking at the clock as readily as by its appearance.

96. The individual articles manufactured for electric cooking certainly **cost** more than ordinary **cooking utensils**, but there is no necessity for having very many of them. With a little management and forethought it is surprising how many of the usual array of cooking pots and pans can be discarded. Once the electric outfit is purchased, it will need renewal only a third as often as the others, owing to its careful manufacture and good material.

97. Descriptions have appeared in magazines and papers of "electric homes" where the **dining room is fitted** with electric wires and plugs **for electric cooking**. The switches controlling the plugs are placed just under the edge of the table, where they can be conveniently manipulated, and yet are out of sight, hidden by the tablecloth. The main wires are taken down in heavy flexible cord to a flush receptacle placed in the floor under the center of the table.

98. In one of these electric homes a small side table was *wired for the* same purpose, and arrangements such as these

are very likely to become much more general in the future, as the convenience to the mistress of the house to be able to prepare the breakfast in the dining room without going into the kitchen at all is obvious. Furthermore, the comfort and ease with which a light meal can be prepared at irregular hours is a great boon. It is not by any means a necessity to have the dining table wired as described above. That is done merely for greater convenience. The wires may be carried to the lighting socket instead, or across the floor to a plug in the wall. When the cooking is finished, the wires can be entirely removed; they need not, and should not, be left connected at either end, since there is no difficulty or delay in connecting them up again. The connecting wire has a plug at either end, one to be fitted to the chafing dish, or whatever appliance is in use, and the other to be fitted to the wall plug; it is but half a minute's work to place these in position, and the apparatus is ready for use. Cookery in the dining room by electricity is rendered practicable because of the ease with which the apparatus is set up, the cleanly and attractive appearance of all the utensils, and the freedom from all smoke or fumes which characterize the use of electricity. As the Irish cook said, "When you smell a stove that doesn't smell, that's electric." There is no danger of electric cooking utensils doing any damage to the polish of the dining table, as they are all mounted on legs with non-conducting knobs.

99. Electric plate warmers are convenient and inexpensive to operate and are very useful **in the pantry**. When dinner is delayed for any cause, plates and food can be kept warm while waiting.

ELECTRIC HEATING AS APPLIED TO COMMERCIAL AND OTHER PURPOSES

100. In the majority of trades heat is required at some stage of the work to a greater or less degree, and electricity will be found a most efficient means of supplying the degree of heat desired, without any delay, fumes, danger, or risk of fire.

101. The electric **tailor's goose** is fast becoming an important factor in the manufacture of clothing. By its use

the liability to damage by soot is eliminated and the gene temperature of the room is not raised. Electric **hatte irons** and **laundry flatirons** of every description are a gr factor in the improvement, the amount and quality of work done. In the laundry the rolls as well as the flatirc should be heated electrically, for electric heat is alw uniform. Gas-heated laundry machinery can easily adapted to electric heating.

102. **Cost of operating** electric irons is less than the cost coal for laundry stove when used only to heat irons. It h been estimated that each worker with ordinary sadirc loses one minute out of every ten trying to keep them at t right temperature for use. This means over a month in ea year. Electric irons maintain their proper heat steadily.

103. No journeying to and from the stove for h irons; no scraping or waxing; quicker, cleaner, and cool work than by any other method. The irons are simple construction, convenient, durable, and reliable.

104. **Cooking by electricity** is to be strongly recommend for **hotels and restaurants**. The electric cooking has alrea been dealt with in the remarks on household cooking, a the same rules apply to hotel cooking. It is therefore u necessary to go over the ground again. There are soi adaptations of electric heating, however, which are of gre service in hotels and restaurants, though not needed private residences.

105. The electric **carving table** and hot cupboard ha been found indispensable in large hotels and restaurants.

106. The electric **drying table** is especially adapted for u by metal workers and printers; also tobacco and chocola manufacturers.

107. To the hairdresser electric heat is serviceable wh shampooing to **dry the hair**, and for heating curli tongs.

108. In the dressing rooms of theaters the combin **curling iron heater and grease paint heater** has been four very satisfactory and entirely safe.

109. The **cigar lighter** is a small portable article that ca be operated by pressing a button on the side and can l attached to a lamp socket.

110. ***Embossing* press heaters**, bakers, **testing ovens**, ar

furnaces for jewelers, manufacturing chemists, assayers, workshops, etc., can all be obtained for heating electrically.

111. Electric **pitch kettles** are cheaper, safer, and better in every way than those heated by other means, as the superheated steam or flame types are more difficult to control, and are accompanied by a certain amount of danger, beside being in no respect equal in convenience and other advantages to the electrical method.

112. Electric **melting pots** are exceedingly useful for melting small quantities of solder, babbitt metal, and similar alloys which have hitherto required the use of charcoal, gas, or gasoline furnaces. Pots heated by gas or gasoline are not only dirty and dangerous, but are also difficult to maintain at a temperature where the least amount of oxide is formed, and yet where the metal is kept in the proper shape for use.

113. The electric **soldering iron** also commends itself because of its continuously applied heat and the avoidance of the trouble called " burning up the tip."

114. For **branding tools** copper can be used with electric heat and is much superior to iron because it absorbs and conducts heat more evenly and rapidly. The constant temperature obtained permits of more rapid and accurate work.

115. In book binderies, piano factories, brush factories, etc., the electric **glue pot** is of great service. There is no risk of fire as with pots heated by gas or gasoline, and the electric glue pot can be safely used among shavings, can be put down anywhere, and is not wasteful. With steam and gas heated glue pots all the glue that runs over the sides becomes baked hard so that it has to be thrown away.

116. Electric **sealing wax heaters** have proved most efficient and reliable It is impossible to overheat the wax they contain, and the saving effected in this way as compared with those heated by gas is sufficient to warrant their adoption.

117. Two other processes for which electric heat is most practicable are the distilling of water and the heating of Turkish and other baths.

118. The **electric still** is exceedingly simple in construction and is therefore unlikely to break down or get out of order. By its use even the dirtiest water may be made pure and sparkling, free from germs and infecting matter.

119. **For heating various kinds of baths** electricity is invaluable. By means of a portable electric hot air cabinet the luxury of a Turkish bath can be enjoyed as readily, cheaply, and often as by any gas, coal, or oil stove. The sand bath and ordinary water bath are heated by means of coils electrically heated and immersed in water or sand.

120. **Pyrography** is a very popular occupation even when gasoline, with its fumes and disagreeable odor, has to be used to heat the stylus; but the work will become still more fascinating if the electric stylus is used, as it can be kept at a uniform heat so that the whole attention of the artist can be given to the drawing. The work is both easier and more agreeable, while there is no danger of explosion which always accompanies the use of gasoline.

121. **Electric welding** meets a long-felt want in many branches of industrial work, the weld being effected quickly and uniformly without risk of overheating, or the consequent formation of an excess of scale or a deterioration of the physical properties of the materials welded.

122. The greatest degree of heat attainable to-day is that generated in the **electric furnace**, and many processes are made possible owing to the availability of the high temperatures obtained in this way, at comparatively low cost. Calcium carbide and aluminum are two well-known products of the electric furnace. It is also being extensively used in the manufacture of tool steel.

123. Electric heat can be more readily and conveniently employed for **medical purposes**, such as cauterizing operations, than any other form of heat, because it can be kept under perfect control and can be applied without loss of time. Electric heat is also of great convenience for sterilizing clinical thermometers, needles, dentist's lancets, and other surgical instruments. There has been a great demand for these in hospital work. The electric bronchitis kettle is a valuable invention, as is the electric heating pad, which replaces the old-fashioned hot water bottle. The dentist will appreciate the value of electric heat as applied in the electric muffle furnace for fusing mineral bodies and enamels.

124. These are a few of the methods in which electric heat may be used advantageously in practically every place of business. In the modern stress of competition the success-

ful men are those who keep up with the times. It is said that "a bad workman finds fault with his tools," but it is also true that a good workman takes care to provide himself with good tools, and **electricity is a good tool** of which all who wish to succeed will be wise to make use.

ELECTRIC MOTORS

125. The electric motor transforms electric energy into mechanical energy and competes with the gas engine, the steam engine, and the water motor. As far as the machine itself is concerned, it is more desirable in every way than any of its competitors. It is efficient, safe, clean, noiseless, flexible, and perfectly controllable. The cost of the energy is usually higher than that used in the other machines, but as a rule the **economy of operation** is such that a given result is obtained for less money with an electric motor than with any other kind.

126. When prospective customers begin talking about the **energy cost**, make sure that their assumptions are correct. Their estimates are usually figured thus: the maximum power required by the machines to be driven is multiplied by the time they are in operation, and this taken as the energy required. Of course, it is way too high, since apart from the fact that machines are usually over-rated, they are rarely operated at full load; the average usually falling below 50 or even 30 per cent of full load. If the cost of operating the installed equipment is divided by this energy figure, an absurdly low cost per unit energy is obtained; or, if the energy figure is multiplied by the price per kilowatt-hour, a correspondingly high figure for central station service is obtained; both these results being unfavorable to the central station. Too great stress cannot be laid on this point when soliciting business from people operating an isolated plant which shows abnormally low costs per unit energy.

THE ELECTRIC MOTOR COMPARED WITH THE ISOLATED STEAM PLANT

127. The **first cost** of an electric motor equipment is very much lower than that of an isolated plant. The cost of power plant **maintenance** is eliminated, the attendance of electric motors being such a small item as scarcely to be considered.

128. The valuable **space** occupied by the engines and boilers can be utilized for business or manufacturing purposes, and thus rendered productive.

129. The **capacity** of the isolated plant is fixed, while that of the central station is practically unlimited, and any increases in business can be immediately taken care of.

130. The **reliability** of an isolated plant often depends on a single engine or boiler, and sometimes on so small a thing as a belt or pair of gears, the failure of any one of which will hold up the entire plant anywhere from a few minutes to several days, during which time the total production is a loss. With electric motors connected to a large central station having all possible provisions for prevention of shutdowns, an occurrence of this kind is practically impossible.

131. In the isolated plant in order to keep down the excessive **losses in shafting, gears, and belting,** machines must be located so as to simplify the driving gear as much as possible. This prevents machines from being located in positions most favorable for economical manufacture. With a motor drive the machines can be placed with regard to economy of time and labor in handling the materials, and entirely independent of the machine drive.

132. **Insurance rates** on isolated plants are higher than on plants where the electric motor connected to a central station service is used.

133. In the isolated plant it may be necessary to keep one boiler and engine and all the shafting running in order to operate a single machine. With individual motor drive only that amount of energy is paid for which is used in doing useful work, the efficiency of the motor being so high that the loss is practically negligible.

ELECTRIC MOTOR COMPARED WITH THE GAS OR GASOLINE ENGINE

The **greatest limitation of the gas engine** is that it : be appreciably overloaded, and operates econom- ɔnly at or very near full load. The electric motor is for its overload capacity. The load which it can :s limited only by the amount of heat which it can :, and therefore for short periods of time it can carry ve overloads.

The gas engine as frequently erected **is noisy, bulky,** t to continuous **vibration,** and requires an especially :**oundation**; while the electric motor is practically ss, occupies small space, requires no foundation, can ced on the floor, wall, or ceiling, wherever most con- t for the work. The **gas engine** must be **started by** unless compressed air or other external power is l; while the electric motor will start with full load ply throwing in a switch.

The **mechanism of a gas engine is complicated** and to repair, the ignition is often uncertain, and without ious circulation of water around the cylinder and nes inside of the piston, the machine will stop or y destroy itself. None of these criticisms apply motor; its construction being simplicity itself.

The proximity of gasoline increases the fire risk, e exhaust must be piped out of doors, both of which ıntages are eliminated with the electric motor.

Makers of **internal combustion engines** often guar- 'ery low **cost per unit of energy** produced. However, gures apply only when the engine is operating under ıvorable conditions as regards load, quality of fuel, nent of the mixture, the ignition, etc. When operat- ler average conditions with different kind of fuel and curate adjustment of the parts, the cost per unit may be nearly twice the guaranteed figure. Taking o consideration, and also the fact that the first cost internal combustion engine is nearly double that of tric motor of equal rating, it is seen that even on *is of cost of energy,* the electric motor under operat-

ing conditions gives more favorable results than the internal combustion engine. In the following paragraphs the comparison between the gasoline engine and the electric motor is taken up more in detail.

139. **Fire Risk.** — The vapor from one pint of gasoline will render 200 cubic feet of air explosive. At ordinary temperature, and where exposed to the air, gasoline continually gives off inflammable vapor, and a light some distance from the liquid may ignite it through the medium of this vapor. It depends only upon the proportion of air and vapor as to whether it becomes a burning gas or a destructive explosive. Hence, there exists an ever present danger from leaky supply tanks, valves, and tubing, and from the explosive vapor of the exhaust itself. Gasoline is particularly dangerous when used in the gravity or carbureter system. In locations where dust or inflammable flyings are present, the engine must be inclosed in a fire-proof compartment.

140. The induction motor is absolutely sparkless; the direct current motor is practically sparkless at all ordinary loads. In cases where it is desired to use the direct current motor and extreme caution is rendered necessary, the motor may be fully inclosed so as to be dust- and water-proof. Fire risk from wiring of the motor itself is a negligible quantity where any reasonable amount of care is exercised in the installation. This feature of the electric motor makes it peculiarly adapted for installation in locations where the use of a gasoline engine would be utterly prohibitive owing to the inflammable nature of its fuel supply.

141. **Noise, Odor, etc.** — A gas engine is preëminently noisy on account of the explosive action upon which its operation depends. (While mufflers may be used, they do not always effectively cure the noise evil while they greatly decrease the efficiency of the engine by introducing back pressure.) The odor and vibration of a gas engine also offer unanswerable arguments against its use in locations where cleanliness and quiet are indispensable. The vibratory effect of gas engines is so serious as to at times preclude their use unless the installation can be made on solid ground, and the engine mounted on a suitable brick or stone foundation.

A gas engine, by its nature and construction, is not so sightly and clean as an electric motor. On the above scores a gas engine affords no arguments for favorable comparison with the electric motor.

142. The slight **noise** made by an **electric motor** is traceable to three principal causes; namely, brush friction, magnetic hum, and windage. Windage is a negligible quantity at ordinary speeds. Brush noise on a well-cared-for commutator is trifling. Magnetic hum in a well-designed motor is not appreciable. The electric motor has no valves or reciprocating parts to cause vibration. It has no noisy exhaust, is absolutely odorless, and its general construction is such that the most perfect cleanliness is possible.

143. Overload Capacity. — A gasoline engine will usually carry no more than its rated horsepower output. Consequently it must in many cases be of such size as to supply the maximum call for power. For example, if eight horsepower is the average power required in the shop, with an occasional demand for 16 horsepower, it would be necessary to install a 16-horsepower gasoline engine with resultant increase in first cost and decrease in efficiency, when carrying the ordinary working load. A gasoline engine, if slightly overtaxed, stops, — obviously a serious handicap in a shop where continuity of power for labor is necessary to sustain the maximum limit of production.

144. The alternating or the direct current **electric motor** will carry comparatively heavy temporary **overloads** without injury or great diminution in speed. A well-designed direct current shunt motor will maintain 25 per cent overload continuously and about 50 per cent overload temporarily without permanent injury or appreciable drop in speed. Therefore, it follows that to fill the normal requirements there may be installed an electric motor of such size that the average load will be carried at high efficiency, and sufficient margin of power will at the same time be available for occasional peak loads without increasing the first cost of the motor or making necessary its normal operation at partial load with resultant drop in efficiency.

145. Weight and Bulk. — Conservatively stated, a gas engine weighs at least 50 per cent more than an electric motor of equivalent horsepower and speed. This difference

in weight is more apparent in the larger sizes than in the small units herein treated. Gas engines, in addition to the large floor space which they occupy, can be set up only in an accessible location and mounted upright on a solid foundation. Gas engines have a multiplicity of parts for repair and attention, out of all proportion to those of the electric motor.

146. The electric motor, due to its simplicity of design, few parts, and rigid and compact construction, is much lighter and occupies much less space than steam, gas, or gasoline engines. The electric motor, owing to its symmetrical design and comparatively light weight, may be fastened to the floor, wall, or ceiling at will, and in locations where the installation of an engine would be impossible.

147. Starting Characteristics — Speed Variation. — Gasoline engines are not self-starting; hence, a loose pulley or clutch device must be used to enable the machine to reach full speed before taking the load. Furthermore, as the flywheel has first to be rotated by hand, the engine must always be situated so as to be readily accessible, a most undesirable feature where limited floor space or other local conditions demand the installation of the driving power in an out-of-the-way place.

Gasoline engines are, by the nature of their construction, constant speed machines, and this limits their use to group drives, and precludes direct connection to variable speed machines unless expensive and often cumbersome mechanical speed-changing devices are employed.

148. The induction motor is the acme of **simplicity** in regard to starting, one switch being all that is necessary to put it in motion. Motors of the direct current type require, in addition, only the manipulation of a starting rheostat. In either case, the operation of starting and bringing up to speed is accomplished quickly and without trouble or physical exertion. The switch or starting box may be placed without regard to the situation of the motor, an argument of weight when the motor has to be fastened on wall or ceiling, or where it is not easily accessible. Where variation in the speed of the driven machine is desired, the direct or alternating current motor may, with economy and ease of manipulation, fully meet all ordinary requirements.

49. **Reliability of Operation.**—The gas engine is a com-
:ated collection of springs, valves, and rubbing surfaces,
subject to the most severe treatment. There must be
:ts for the air and gas, and an outlet for the exhaust.
e sparking mechanism is delicate and very apt to get
of order. The explosive force, on which the engine
ends for its operation, is of a violent nature and tends
rack and soon wear out the mechanism. So far, all
losive engines are alike.
A large proportion of gasoline engines are of the "hit
l miss" type, and consequently are rather unreliable for
ring machines where fine speed regulation is demanded.
a general statement, the straight gas engine gives better
ed regulation than the gasoline engine.
50. The electric motor contains no valves, intricate
erning mechanisms, or reciprocating parts necessitating
tinual lubrication or repair. The attention required to
ire satisfactory operation from the electric motor is
ctically limited to the occasional filling of two oil wells.
: simplicity of its parts and the slight possibility of dis-
ingement of the electric motor make it more nearly
olutely reliable than any other power.
51. **Repair and Depreciation.**—The opportunities for
akage of gas engines are undesirably excessive as com-
ed with the electric motor. In water-cooled engines,
uld the water by any means fail, the apparatus is fre-
:ntly ruined, or, at least, the cylinder so injured as to
essitate reboring, which is an expensive and time-taking
ration.
t is suggestive of anticipated trouble from overheated
nders when manufacturers advertise that the "cylinders
made extra heavy to allow for three or four successive
orings." The point might be made that commutators on
:ct current motors may occasionally require turning off,
do cylinders reboring; this is true in a sense. Still the
ration of rounding off a commutator is an extremely
ple and trifling piece of work compared with the time
l skilled labor needed to accurately rebore an engine
nder.
f to the increased **first cost of a gas engine** over an electric
tor be added the heavy annual depreciation, the clair

of low fuel consumption are somewhat discounted. More important than the cost of labor and material for repairs is the often underestimated loss of time due to frequent and annoying shutdowns. For the production of a shop or factory to be maintained at its best efficiency, continuity of operation must be assured.

Injury to cylinders through poor lubrication and trouble with ignition tubes and batteries are fruitful sources of troubles with this type of engine.

152. The **life of a good electric motor** is conservatively estimated at from ten to fifteen years. The renewals that would be needed at the end of such time to put the motor in condition equal to new would not represent, capitalized, the equivalent of more than 5 per cent annual depreciation. Due to the absence of reciprocating parts in an electric motor and also to the very small number of rubbing surfaces of the rotating parts, the wear on a well-constructed machine is exceedingly small. Instances may be readily found where electric motors have operated for years with practically no attention whatsoever.

153. Cost of Installation and Operation.—The installation of a gasoline engine involves heavy foundations, the running of pipes between the engine and water or gasoline tank. To this must be added the erection and connection of the tanks, with all their valves and extra parts; in short, what is equivalent to a small steam engine installation.

The **consumption of gasoline** per horsepower-hour in engines from 1 to 15 hp. varies from a pint to 1.5 pints, depending upon the make of engine, number of cylinders, and the thermal value of the gasoline. It is difficult to obtain reliable data as to the expense of operating gas or gasoline engines outside of the actual amount of gas or gasoline consumed per horsepower-hour. (Note.—In point of economy natural gas stands first, then gasoline, illuminating gas, and producer gas.) These items are pretty definitely known, yet, as will be seen from the following extract from a letter written on this subject by a user of a gasoline engine, there may exist a wide variation between the maker's guarantees and the actual performance. "A 12-hp. gasoline engine was installed, the engine company guaranteeing verbally that *with gasoline* from 10 to 12 cents per gallon the engine would

cost 1 cent per hour to operate. The engine is at present developing only about 7 hp. Figuring on the basis of the manufacturer's guarantee and estimating nine hours' work per day, gasoline should cost 63 cents per day, or $3.78 per week. The proprietor stated that he estimated a weekly consumption of 75 gallons of gasoline, the books of the factory showing this to be a fair average. Gasoline costs 14.5 cents per gallon, delivered. Taking into account the cost as shown by the preceding statement, the weekly cost of energy amounts to $10.87. This shows a wide variation between the maker's statement and the actual performance." It may be here noted that gasoline engines are very inefficient when operated at partial loads.

In many locations, the vapor and odor of gasoline occasions loss by deteriorating the manufactured product.

In most cities water is expensive when supplied from city mains, and its charge for cooling purposes is simply a continual waste.

If dry batteries are used for ignition, the cost for these is often a very large item.

154. The **electric motor** is quickly and cheaply **installed**, requires no stone or brick foundation or any particularly fine alignment. If subsequently desired, it may be moved from one machine or location to another with the greatest ease. The foregoing remarks apply equally to the wiring and controlling devices, which are of the simplest description.

When the use of electric energy at a reasonable price is possible, the electric motor should compete quite well with gas or gasoline under ordinary conditions. However, the cost of gas or gasoline, as expressed in gallons per horsepower-hour, is an unfair indication of the total expenditure, as the users of this class of apparatus as a rule keep account of only the quantity of fuel used, disregarding entirely such important items as oil, repairs, loss of time in starting, depreciation, etc. These items, while of small consequence with the electric motor, are of material importance in determining the actual cost of operating explosive engines.

The electric motor provides a margin for occasional heavy overloads without necessity of extra initial outlay for a motor *larger than necessary* to handle the average requirements.

The electric motor does not in any way damage the manufactured product.

The first cost of the electric motor is much less than the cost of the gasoline engine.

The electric motor occupies less available floor space and wastes no time in starting. The cost for oil, attendance, and depreciation is much less. The use of electricity decreases fire risk, and consequently reduces insurance rates.

155. A great deal has been said about the high economy of the **suction gas engine**. The engine itself does not differ materially from the ordinary gas engine except as regards the supply of gas. The engine is connected directly to a suction producer, the piston sucking the gas through the producer. This is a very neat arrangement and works out admirably when the engine is running at or slightly below full load. At overload the engine stops, and at loads below one half it will stop, because an insufficient amount of gas is taken to keep the producer generating.

THE ELECTRIC MOTOR IN FACTORIES

156. There is no **problem** of more vital interest to the **small manufacturer**, repair shop man, or user of light machinery than that of obtaining a cheap, reliable, simple, and continuous source of energy. This question is often the dominating factor in determining the location of a shop or manufactory. Nearly everything else is subservient to it. There are throughout this country thousands of mechanics and manufacturers using light machinery, who are quartered in out-of-the-way, low-studded, badly ventilated, and badly lighted shops for the reason that it is only in such locations that they can find shafting to which they can attach their machines and from which they may obtain the necessary energy to operate them at a reasonable cost.

157. Aside from the prejudicial effects to **health and eyesight** arising from working in such unhygienic surroundings, they are a positive and serious detriment to a man's business success. People do not like to enter gloomy, out-of-the-way, ill-ventilated, and dirty shops to place their orders or look for such articles as they may be in search of. A pleasant, well-

lighted and well-ventilated, easily accessible store or factory is an absolute necessity to any man desirous of making the most of his business. Even if a room be clean, light, and well-ventilated at the start, it soon becomes gloomy and dirty if energy is supplied to its occupant from the time-honored line shaft, with its attendant heavy belts, frictional electricity, constant dust, and dropping oil.

158. With the advent of **the electric motor** the necessity for putting up with these conditions is largely eliminated. In all of our principal cities and towns there are electric stations from which a supply of electric energy may be readily obtained for operating motors. These motors may be, and often are, directly connected to the machines, thereby doing away with belting. Where this is impracticable, the shafting and connecting belts may be of the lightest character, and then only of the size and number absolutely necessary for local requirements. They may be chosen without any regard to transmitting energy from room to room or over long distances.

159. There are thousands of well-lighted, well-ventilated, easily accessible **locations for small shops or factories** throughout our large cities and towns, which could be rented at a low price and which would serve admirably as locations for small mechanics and manufacturers, did they possess the one vital element — energy supply.

160. The electric motor enables one to set aside this limiting feature entirely, for he may locate his factory or shop wherever he desires, and by the use of the small, unobtrusive motor, have at his command a continuous, clean, and economical service available in many cases twenty-four hours per day.

Under the old method of **energy from a shaft** driven by a steam engine, a tenant must estimate what his prospective wants will be, and then the landlord will make him a rate based on the maximum requirements of his work; for, as the engine furnishing energy for the building is a strictly local institution, there is no other outlet for the energy which it furnishes save on the premises, and the landlord, in providing for the maximum requirements of all his tenants, must charge them accordingly. That is, the landlord must *have at command* at all times power virtually eq

the maximum which his tenants will use, and each tena must, therefore, pay for his proportion whether he uses it o not.

161. With the electric motor deriving its energy fro a central station which supplies perhaps hundreds of cu tomers, there is a great deal of **flexibility** in the matter o power. All of the consumers are never using the maximu at the same time; hence the station is not obliged to maintai relatively so large and expensive a reserve, to be paid fo *pro rata* by its customers. Electric energy for operatin the motor can be supplied through a meter which is a reliab register of energy consumed, and is as accurate as any piec of apparatus of similar nature can be. When the switc governing the motor is closed, the energy immediately begin to flow, but the motor, being an automatic mechanism, take **energy** only **in proportion to** the amount of **work** it is doing hence, the meter connected with it will record a charg proportional to the work actually being done.

162. As **an illustration**, take the case of a circular saw Ordinarily a mechanic has to pay his landlord for power t the full rating of the saw; say, five horsepower. If hi business is such that he always saws hardwood planks thre inches thick, we will say, and is doing it ten hours per da constantly, then the charge which he pays is reasonabl and just, but if his business is of such a nature that he onl occasionally saws such a plank, more often saws half-incl pine, and perhaps for hours has his saw remaining idle then in the case of steam he is paying a sum largely in excess of what he ought to pay. If his saw were driver by an electric motor, energy would be charged for at th full rate only while he was doing the heavy work. Whe he was doing the light work, the meter would charge u energy at perhaps only one half of one horsepower, and whe the saw was still, absolutely nothing would be charged up

163 The same argument in favor of the electric moto applies to all classes of machinery, lathes, planers, die an printing presses, sewing machines, paint mills, buff wheels metal rollers, paper cutters, and the thousand and on different types of machines which are to be found amon the various small shops and factories.

164. *It is immaterial* whether the tenant hires a room o

the first, second, or third floor, or in the basement; one place is just as accessible for the power as another, for **wires can be run anywhere**, and extension shafts, mule pulleys, skew belts, and other like power-wasting devices are avoided.

165. Again, each tenant in a building supplied with steam is absolutely dependent, so far as his own energy is concerned, on the operation of one engine with its attendant main shafts and belts. If any of them give out, then every tenant must stop work until repairs can be made. In the case of motor-driven machinery the problem is entirely different. Stations are equipped with duplicate and even triplicate machinery, and a combination of circumstances is scarcely conceivable, which will deprive the customer of energy; in fact, investigation will show that motors driven from central stations furnish the most reliable energy obtainable.

166. In the present day of keen **competition** it is necessary for tradespeople to take every advantage possible in promoting their business. The location of their warerooms or factories must be on the path of travel and easily accessible; every item of expenditure must be carefully gauged, and they must rid themselves of any charges for energy or rent which are not absolutely necessary.

167. In the case of an **engine driven building**, with a number of tenants there located, the landlord must plan, when making his schedule of rent, so that each tenant shall pay his proportional part of the heavy maintenance for the energy-distributing system, including shafting, belting, and pulleys, together with a sufficient additional amount to recoup him for energy unrented and rents uncollectible.

168. It is no unusual thing to find thirty and even fifty per cent of the capacity developed by an engine **wasted in jack and main shafts**, heavy belts, mule pulleys, and other devices required to distribute the energy over many floors and to many tenants of a large building. For the remaining net energy available for the use of tenants, a proportionally higher rate must be made to cover these losses.

169. In the case of an **electrically driven building**, each tenant pays simply for the energy which he consumes; he is independent of his landlord so far as being obliged to *make good the losses* of the kind enumerated above. and

his energy business is transacted independently of the man of whom he rents his rooms.

170. Central stations are, as a rule, very moderate in their **charges for connecting motors** to their circuits. They will run wires any reasonable distance, and will make a meter rate which is very attractive. In any event, the buyer of electric energy knows to a certainty that he is paying only for energy he actually uses from minute to minute, and that the size of his energy bill is in his own hands. If he is careful to shut down his machinery when it is not in use, he can limit his expenses in this regard to the absolute cost of energy required while the work is on the machine. Furthermore, the electric motor can be directly connected to many machines without the use of belts, or the shafting and belting can be made so light that one pays for practically no unproductive energy, and in this alone a very great saving can be made over the use of steam power where a great many shafts and belts intervene between the prime mover and the lathe, saw, or other machine on which the work is actually done.

171. The foregoing remarks in regard to losses of energy in engine-driven establishments apply particularly to buildings which have been erected and used for a number of years. In such buildings the floor timbers have usually sagged, and the shafting has become out of line to an extent which renders it practically impossible, without completely reëquipping the building, to remove abnormal friction losses. **Old buildings**, furthermore, lose their rigidity, and the floors are constantly changing form due to the moving about of completed stock or material in process of manufacture. This results in frequent change of shaft alignment and heavy friction losses.

172. In many instances **energy is conveyed to** machines in a **remote part of the building**, or even to machines located in a separate building, by systems of shafts and belts or rope transmission, which, in themselves, consume far more energy continually than is used intermittently by the machines which they are intended to drive. The use of electric motors obviates these losses.

173. Many industries require the use of machinery in the *preparation of* raw material only a small part of the working

day. The shafting and belting necessary for driving them, however, are constantly in operation, and under such circumstances the electric drive is particularly desirable.

174. When energy is supplied to machinery from an engine, it is very difficult to ascertain whether the machinery is working at its best or not, and whether there are any undue friction loads developing. If a motor is driving machinery, however, it is very easy to **determine** from time to time the amount of **power consumed** when the machines are running light, and if this amount shows a perceptible increase, it indicates at once that there is undue friction which can be easily located and the necessary remedy applied. This, in itself, is a very valuable feature of electric driving, as it often discovers, especially in shops running on piece work, the abuse of lathes, screw machines, etc., by the piece workers having care of them. As lathes, screw machines, saws, drills, and, in fact, the greater number of machines ordinarily required in a shop, run at comparatively high speeds, less belts and pulleys are necessary for actuating them when driven by motors which have a rather rapid rotation, than is necessary when they are driven by shafts which rarely revolve more than 240 times a minute.

175. The **flexibility of a motor system** is also of the greatest advantage. There is hardly a shop where frequent changes are not made either by putting in additional machinery, or changing the location of the existing machines. When such machines are driven by motors, however, it is far easier to change the wire circuits supplying them than to change a line of shafting with its attendant pulleys and belts. Furthermore, in **engine-driven shops** the entire location and layout of a machine tool plant has to be dependent upon the relative accessibility to and location of the driving shaft. This often results in the necessity of arranging the machines most disadvantageously, so far as a strict regard to the sequence of operations to be carried on is concerned. Motor-driven tools may be located to the utmost advantage in relation to the general layout of the shop, and without regard to a line shaft. As motors may be attached to the wall or ceiling, the belts will be short and the pulleys small, causing a material saving in floor and *ceiling space.* The practicability of motor driving is now

so well established that a great many concerns formerly tied down to disadvantageous and unhealthful situations are adopting electric motors for power purposes, thereby enabling them to enjoy light, air, and locations easily accessible to their customers.

ELECTRIC MOTOR IN THE HOUSEHOLD

176. When once an electric motor has been installed in a home, a great many uses will be found for it not previously anticipated. The energy consumption is comparatively small, while in addition to the labor saved the convenience is a great item.

177. For the driving of various **household labor-saving devices** and conveniences, such as coffee grinders, meat choppers, knife cleaners, boot polishers, polishers and buffers, icecream freezers, small potato and vegetable peelers, small dish washers, and other machines which are not in use very long at a time, it is well to arrange the motor in a definite position on a table, or on a wall just above a table, in a kitchen or any room where the work is to be done.

178. Electric light and electric heat do much to facilitate the work of the modern house, but there are many household duties which these cannot lighten, and here appears the need of the electric motor. Electric motors are small, compact machines that can easily be moved from one part of the house to another. They are not complicated in construction, difficult to clean, nor liable to get out of order. No such difficulties have to be reckoned with when motors are called upon to do their share of the household drudgery. They are easily adjusted for any work required, and connection with electric circuits is a simple matter.

179. The uses to which an electric motor can be put in the house are numerous. On washday it can be carried into the wash house and fixed to **the washing machine or the mangle**. It stands on the floor underneath the machine which it is driving and is therefore out of the way. By means of a pulley on the motor connected by a leather belt to the pulley on the washing machine, the motor operates the machine, and the work is done in a very short time at a small cost, and without fatigue to the worker.

180. The same motor will serve for the **polisher or buffer.** 'he article to be cleaned is simply held against the rapidly ;volving buff and turned about as required, the polishing eing done with practically no trouble at all.

181. Coffee can be ground, meat chopped, shoes shined, nd knives polished by using a small motor to drive the arious machines. One of the most **popular uses** of the ıotor is for running the sewing machine, and one that is ecoming deservedly popular is its application to house .eaning. An entire house can be cleaned and thoroughly usted by means of the motor-driven vacuum cleaner, a ortable apparatus that sucks up dust and dirt through a ozzle attached by a hose to a small pump.

182. The **electric fan** must not be overlooked, for it has roved itself invaluable, with its cooling breezes in summer nd its power of distributing warm air in winter, or exausting the foul air.

183. **House pumps** are daily becoming more necessary wing to the inability of existing water works plants to aintain a good service under rapidly changing conditions used by growth of towns and increasing height of buildings. 1 order to make up for low or variable water pressure in high or outlying building, such as an apartment house, for stance, it is customary to install a small house pump for e purpose of raising the pressure; or for filling storage nks situated at the top of the building. With electric otors it is easy automatically to maintain the head of water nstant. The motor is arranged to start when the head water falls below a certain minimum, and to stop when has reached a predetermined maximum, thus reducing e item of attendance practically to zero.

184. The electric laundry or **washing machine** which as heretofore been used in public laundries, hotels, hospitals, nd other large institutions exclusively, is now coming into ore general use. The present low price is bringing it to the household laundry, where it is found to be an valuable companion to the electric iron which has already een installed in many homes.

185. The ball-bearing type of **rotary washer** can be perated by a one-tenth horsepower electric motor at a cost f *about two cents* per hour. Now an ordinary washing

consists of from three to five tubfuls of clothes, and with an electric washing outfit each tubful needs but from eight to ten minutes' work, so that the entire work can be completed in from thirty to fifty minutes. By the old method a couple of hours at least were consumed.

186. The electrically driven **sewing machine is a great** boon to its operator, as it relieves the sewer of the wearisome and harmful foot movement. The cost of operation is almost negligible, as it consumes very little more energy than an ordinary incandescent lamp, while the amount of work it will accomplish is marvelous.

187. The sewing machine motor is bringing about a new era in factory conditions, as many women can now, by the aid of the electric motor, do the work at home. In one small city alone about two hundred sewing machine motors have been installed.

188. A little **electric grinder, polisher, and buffer** is an exceedingly useful device in the house, saving a good deal of elbow grease, and at the same time making the silver, electro-plate, brass, and other bright metal articles, utensils, and fittings even more resplendent than when polished by hand.

189. An **adaptation of the polisher** is the shoe cleaner. By aid of this machine the time required to polish a pair of shoes is very short, and a fine polish is obtained.

THE ELECTRIC FAN

190. The question of **proper ventilation** is one that is especially prominent in these days of careful attention to hygiene. More and more it is being realized that fresh air is one of the most important factors of healthy living.

191. The following figures show the **frequency** with which the air should be **changed in public buildings** to insure health and comfort: —

Large public rooms — every 10 to 20 minutes.
Factories and workshops — every 5 to 20 minutes (according to the work being done).
Shops, offices, halls, and churches — every 20 minutes.

179. To **ventilate** a **public building** to this extent **without** giving rise to complaints from the numerous persons who are sensitive to **draughts** has not in the past been an easy task. But the electric fan offers a simple solution of all difficulties in the way of ventilation; it can be fixed in any out-of-the-way position and controlled from any convenient point; it is silent and its simplicity of construction is such that it seldom gets out of order; moreover, it does its work at an extremely low cost, and it can be switched on or off with the greatest ease. The operation is so simple that a child can manage it.

180. Exhaust fans are now extensively used in factories, public buildings, and offices, and also in hotels, restaurants, and saloons; in fact by all who wish to attract customers. Proprietors of such establishments realize that pure air is desirable for the comfort of patrons as well as for their health and that of employees.

194. The **initial cost** of an electric exhaust fan is lower than that of any other apparatus moving an equal amount of air.

195. For use in smaller buildings and in private houses there are small **table fans** which require only one trial to be fully appreciated. These can readily be attached to the electric lamp circuit.

196. A small type of **fan** is also made **for** fixing to the ordinary **lamp socket** in place of the lamp.

197. Portable fans are sometimes used in shop windows for blowing about streamers of ribbons, flags, or toy balloons, thus forming a most effective and eye-catching advertisement.

198. The small **fans** are useful in **chilly weather** as well as in hot weather, as they can be placed beside the radiator to disseminate the warm air rapidly through the room.

199. Storekeepers and especially **florists** will find the small fan very serviceable in the winter months for the purpose of frustrating the artistic efforts of Jack Frost upon their window panes. For beautiful as these may be in themselves, they conceal the contents of the windows from the gaze of passers-by. Therefore the storekeeper will appreciate the value of an electric fan which, by maintaining a constant circulation of air between the window and the store, prevents any moisture from settling and congealing *upon the glass.*

ELECTRIC ENERGY IN MEDICINE

200. The up-to-date **doctor's office** often looks like an electrical testing laboratory. Among his **equipment** will usually be found induction coils of various **sizes**, vibrator motors, motor drills, motor generator sets, **static machines**, storage batteries, condensers, inductance coils, lamps of various descriptions, cauterizers, and other heating apparatus.

201. **Mechanical and electrical therapy** are coming more and more into use for treating chronic ailments, and the results thus far obtained are such as to cause the greatest hopes for the future of this kind of treatment to be entertained.

202. In this field electricity has no **competitor**, for the science itself is built on electricity. All the solicitor has to do is to post himself on the subject of electro-therapy, and then keep the physician informed of all the new and improved apparatus that comes out.

SECTION 3

ILLUMINATING ENGINEERING

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ILLUMINATING ENGINEERING

PRINCIPLES

1. **Illuminating engineering** is the art of using artificial illuminants. The theory of illumination is not new, but the profession of illuminating engineer is a comparatively new one. The impracticability of fulfilling the requirements of proper and economical illumination with oil and gas lamps held back the development of the science of illuminating engineering, and at first when the electric lamp was installed in the place of oil and gas lamps, no attempt was made to utilize its possibilities as an ideal illuminant. However, as the industry developed, and more and more different types of lamps were brought out, competition led those interested to resort to the art of illumination to assist them in the fight for supremacy. With such an array of lamps of all styles and shapes, giving light of various colors, intensities, and degrees of brightness, the engineer was forced to take up the study of illumination in order to be able to exercise proper intelligence in the selection and placing of lamps to give a desired result. It was then but a step to the establishment of the profession of illuminating engineering.

2. There are five **fundamental quantities** with which the illuminating engineer has to familiarize himself; namely, quantity of light, flux of light, intensity of the source, brightness of the source, and illumination of the surface to be lighted.

3. The **quantity of light** may be compared to the quantity of electricity, water, or any other energy-carrying medium. It is measured in lumen-hours, which signifies light of unit intensity per unit solid angle (one that subtends a square centimeter at a distance of one centimeter) per hour.

4. The **flux** is the quantity of light per unit time, and is measured in lumens; one lumen represents the flux from a *lamp of unit intensity* included in a unit solid angle.

5. Brightness of Various Illuminants

Source	C. P. per sq. in.	Notes
Sun (in zenith)	600,000	Necessarily rough estimate taking account of absorption
Sun (30 deg. high)	500,000	" " "
Sun (on horizon)	2000	" " "
Electric arc	10,000 to 100,000	Reaching often 200,000 in the crater of a very powerful arc
Calcium light	5000	
Nernst glower	1000	
Incandescent lamps	200 to 500	Depending on efficiency. Some metallic filament lamps run above 1000
Enclosed arc	75 to 100	Including opalescent, inner globe. Very variable
Incandescent mantle	20 to 30	50 and upwards when supplied with gas under pressure
Mercury arc	10 to 13	Vary widely according to quality of gas and oil used
Open gas flames	4 to 8	
Kerosene lamps	4 to 8	
Incandescent frosted globes	2 to 8	Merely a question of density of shades
Opal-shaded lamps	0.5 to 2	" " "
Moore tube	0.5 to 1	" " "

6. The **intensity** of a source of light is measured in candle power, and represents the rate at which luminous energy is given off by a source in terms of a **standard source**. There are several standards now in use, none of which is perfectly satisfactory. The hefner, or German standard, is probably the most reliable. The standards used in practice are incandescent lamps of carefully measured candle power. The candle power of a source is not uniform in all directions, and therefore it does not mean anything unless the direction is stated. There are three ways of rating the candle power of a source, according as it is measured in a horizontal plane; over the surface of a sphere whose center is at the source; or, over the surface of the lower half of the same sphere. The first is called "the mean horizontal candle power," the second "*the mean spherical* candle power," and the third "the

mean hemispherical candle power." The only true measure of the light-giving power of a source is, of course, the mean spherical candle power. The relation of mean spherical candle power to lumens is $\frac{\text{lumens}}{4\pi}$.

7. The **brightness** of a source is measured in candle power per unit area of light-emitting surface. It is generally expressed in candle-power per square inch. The brightness of various well-known sources is given in Table 7.

8. The **illumination** of a surface is measured in terms of that produced by a standard source at unit distance. It is expressed in foot-candles, which unit signifies the illumination produced by a standard candle at a distance of one foot. It must be noted that this is not the product of candles and feet, but that it is always the number of candles at the *constant* distance of one foot. It is, therefore, erroneous and misleading to give this unit as candle-feet, as is often done, instead of foot-candles.

9. When the source is concentrated sufficiently to be considered as a luminous point, the **law of inverse squares** can be applied to determine the illumination on a given surface at a given distance from the source; that is, the illumination in foot-candles of a point at a distance of 10 ft. from an unshaded incandescent lamp giving 16 c. p. in the direction under consideration is

$$\frac{\text{Candle power}}{(\text{Distance})^2} = \frac{16}{10 \times 10} = 0.16 \text{ foot-candle.}$$

10. The intensity of a source in candle power and the distribution of the intensity is determined with a **photometer**, an instrument by which a given lamp may be compared with a standard source. It is beyond the scope of this book to take up the principle and operation of the various forms of photometers, since adequate treatises on this subject are given in several of the illuminating books.

11. By means of the photometer useful **light distribution curves** may be deduced which are instructive and of great value, not only in research work, but also in the practical determination of the location and distribution of illuminants. The effective illuminating power is best determined by *actual observation* and demonstration. A simple example

will illustrate the point. Assume that there are two lamps exactly the same in every respect, except that one throws all its light upward, whereas the other throws all its light downward. The two lamps as measured on the photometer, or on the basis of mean spherical candle power, would be placed on an exactly equal footing. But as a source of effective illumination, obviously the lamp which throws most of its light in the direction of greatest use is the lamp which has the higher practical efficiency.

12. Mr. Haydn Harrison, the well-known lamp expert, in a paper on practical photometry, remarked that many people "are still under the impression that the **comparative value of illuminants** can be judged by looking at them." That is just the unfortunate part about it. Although more thoughtful people were convinced years ago that this was not the case, and therefore devised a photometer, public lighting stands or falls by the judgment of the foolish majority. The average man always stares right into a burner to appraise its power of illumination. He can tell you, at a glance, whether "gas is a more powerful light than electricity," or *vice versa.*

13. Mr. Harrison maintains that if **photometric measurements** are **made in situ**, with lamp globes on and mantles of average age, gas lighting will not be found the serious competitor which it is imagined to be. He further states that he has had many instances of this kind, in several of which, by undertaking to give lamps of equal candle power to that found to be the average of the existing ones, the electric interests have obtained the public lighting, and carried it out to the satisfaction of all parties.

14. The **light emitted** by a lamp must go somewhere and keep going until it **is absorbed**. For instance, a single beam of light leaves the lamp and travels in a straight line perpendicular to the surface from which it was emitted, until it impinges against some medium of different density than the air, such as the wall of the room. At this point a part of the light is absorbed, and the rest is reflected back into the room, where it impinges again against something, loses another part, and so on until all has been absorbed. Given an empty room with plain walls and a source of light in the middle. The amount of light necessary to produce a given illumination depends *entirely upon the* character of the walls. Just that amount of

hich is absorbed must be continually supplied by the . If the air absorbed none, and the walls were perflectors, a given amount of light once introduced into room would continue to light it forever at the same ty, and if the lamp were kept burning, the intensity of ht inside the room would increase indefinitely. These al conditions which can never be realized, but they go w the meaning of reflecting walls and the importance r bearing on the economy of light and, therefore, of energy. The light reflected from a surface in per cent total light falling upon that surface is called the **reflec-efficient**. Table 15 gives a list of reflection coefficients may be useful in judging the comparative value of s kinds of walls.

15. Table of Reflection Coefficients

Material	Coefficient	Material	Coefficient
d silver	92 to 93	Yellow cardboard	30
silvered on back	82 to 88	Light blue cardboard	25
lotting paper	82	Brown cardboard	20
artridge paper	80	Yellow-painted wall, dirty	20
d brass	70 to 75	Emerald-green paper	18
backed with amal-	70	Dark brown paper	13
ry foolscap paper	70	Vermilion paper	12
-yellow paper	62	Bluish green paper	12
paper	50	Cobalt-blue paper	12
wall paper	40	Black paper	5
painted wall	40	Ultramarine blue paper	3.5
ink paper	36	Black velvet	.4

The **color of light** has an important bearing on its ness for a given purpose. In commercial work where have to be compared, as in dry-goods stores, etc., a light must be used. The ordinary incandescent gas owing to the greenish color of the light it gives, is very sed for the purpose of matching and selecting colored The incandescent electric lamp is but a little better, er its rays the delicate shades of pink, green, and blue lly are destroyed. Tantalum and osmium lamps are a *mprovement*, as the light given is whiter. The arc

lamp is undoubtedly the best of all, though sometimes suffering from an excess of violet. This may, however, be counteracted by careful diffusion and absorption, the light being reflected from surfaces coated with a pigment that has a strong selective absorption of violet rays. Golden flame arcs are almost valueless from the color point of view, as they are too rich in yellow rays.

17. When certain artistic effects are to be brought out, sources giving off selective radiation are often desirable. For instance, the green light from the mercury vapor lamp, which makes humans look as though they were dead and putrefied, produces a beautiful effect when used to light foliage in greenhouses.

18. Light containing red gives a sensation of warmth and makes people look rosy and soft-skinned; while green, like that from a Welsbach burner, gives a sensation of cold and makes faces look ghastly and sickly. Table 20 may be of use in judging the comparative value of various illuminants for producing color effects.

19. Starting with a white light, any color can be brought out by using shades which transmit only the color desired. However, shades can only subtract and never add colors. For instance, if a lamp gives no red rays, a red shade will not help matters; it will simply cut off nearly all the light, leaving the room in darkness.

20. Colors of Sources of Light

Source	Color
High sun	White
Low sun	Orange-red
Sky light	Strongly bluish white
Electric arc, short	White
Electric arc, long	Blue-white to violet
Nernst glower	White to yellowish white
Tungsten filament	Nearly white
Carbon filament	Yellowish white
Mercury arc	Blue-green
Welsbach mantle	Greenish white
Gas flame, ordinary	Pale orange-yellow
Kerosene	Pale orange-yellow
Candle	Orange-yellow

ELECTRIC LAMPS

!3. **When a body is heated** above the surroundings, **it iates energy**; at first in the form of heat, and later, when tain wave lengths are reached, a portion of the radiant rgy is in the form of light. Electric energy is easily ›lied to bodies whose temperature it is desired to raise to a nt where they become incandescent and give off light. In electric lamp the electric energy is completely transformed › heat, a large portion of which is given off as radiant rgy. Part of the radiations are visible and constitute ıt; however, a comparatively small proportion of the total rgy is given off in this form. . The maximum radiation rgy approaches visible radiation more and more as the ıperature of the radiating body is increased. It is by reasing the temperature of the filament that its specific sumption in watts per candle power is decreased, and this vhy high efficiency lamps have shorter lives than the less cient lamps of the same kind. The maximum possible ciency would be reached at a temperature of about 6800 . Cent., which no known solid will endure. As a matter fact, the usual temperature at which the filament of an andescent lamp is worked lies between 1550 and 1600 . Cent.

!4. All **electric lamps** may be divided into three fundantal **classes**; namely, arc lamps, filament lamps, and ›or lamps. In the following paragraphs a brief descrip- ı of commercial lamps is given under these three heads.

!5. **Arc Lamps.**—The electric arc of the open type was first electric lamp, and though invented a century ago, been in commercial use for only about thirty years. The est type of arc lamp has attained a high state of perfection, l is used in many places as a standard means of lighting. : lamps can be used on either alternating-current or directrent circuits and for a wide variety of purposes, both for door and interior lighting.

!6. The arc lamp consists of three essential parts: the ctrodes, the mechanism which operates the electrodes, and structure in which these parts are mounted. The **ctrodes** are usually made of carbon, although in some of *later types of lamps* other materials have been used. An

arc is started between the electrodes, and once started, it creates a stream of vapor between them; thus providing a good conducting path for the electricity which continues to flow and maintain the incandescence of the vapor stream. The temperature of the arc is the highest at present attainable (3700 deg. Cent.), and the arc furnace is used commercially for reducing and melting the most refractory substances.

27. Arc lamps may be divided into two general **classes**: open and enclosed. The enclosed type differs from the open type by the addition of a small, tightly fitting glass globe closely surrounding the carbon tips and forming a chamber in which the oxygen is almost instantly exhausted, the globe becoming filled with gases, greatly reducing the consumption of the electrodes. The enclosed arc has the following advantages over the open arc: much greater length of flame, therefore less interruption of light by the lower carbon; more even light distribution; greater steadiness of light, longer life of the electrodes; reduces labor and expense for lamp trimming; safety from flying sparks; absence of carbon dust; and more attractive appearance.

28. The **flaming arc lamp** is, in principle of action and mechanism, the same as the ordinary arc lamp, but instead of using pure carbon electrodes it employs carbons containing calcium salts, producing the golden flame, barium salts, producing the silver flame, and strontium salts, producing a pink flame. Unlike the ordinary carbon electrode lamps, the greater part of the light does not emanate from the incandescent carbon tips, but from the flaming arc itself. These lamps are widely used in Europe and are rapidly increasing in popularity in this country. Their specific consumption, *i.e.* the watts per spherical candle power, is from one half to one fifth as great as that of the ordinary carbon electrode arc lamp, the exact value depending upon the size and color of the lamp. The golden flame lamp has the highest efficiency, the pink next, and then the silver. These lamps are made in two types, — those in which the rod electrodes are coaxial, and those in which they are inclined and fed from above.

29. For purposes of **street illumination** the highly *efficient golden light* of the calcium carbon is in general useful,

but for **interior illumination**, where color values are important, it is objectionable. Under its light white material appears to be cream-colored, the shades of yellow are intensified, and the color values at the violet end of the spectrum are naturally distorted. With the white light flaming carbons, however, most of the colors are very close to the true daylight values.

30. Diffusion of light is somewhat better than in the ordinary carbon lamp, since the area from which the illumination emanates is increased.

31. THE RELATIVE COST OF OPERATING ARC LAMPS
(Mr. L. B. Marks, N.E.L.A., 1906)

Station Cost in Cents of Producing Energy per kw-hr.	Cost of Energy 4000 hrs.		Cost of Energy, Carbons, and Trimming 4000 hrs.			
	One encl'd arc lamp (500 watts)	One flaming arc lamp (100 watts)	One encl'd arc lamp (500 watts)	One flaming arc lamp (100 watts)		
				Cost of carbons per trim		
	Dollars	Dollars	2.75 ct.	10 ct.	8 ct.	5 ct.
2.5	50	10	$52.60	$54.71	$47.41	$36.46
2	40	8	42.60	52.71	45.41	34.46
1.5	30	6	32.60	50.71	43.41	32.46
1	20	4	22.60	48.71	41.41	30.46

32. When considering the use of this type of lamp, the following points should be observed: —

(1) That the flaming carbon arc lamp of commerce produces five times the total luminous flux of the enclosed arc lamp for the same expenditure of electrical energy in the arc.

(2) The lamp is well adapted for purposes of illumination where a flood of light is desirable in a single unit, as, for instance, for advertising purposes.

(3) The lamp may be used economically in the lighting of some large interiors, and in large open spaces, such as public squares and wide boulevards, if the lamps are placed *at a considerable height*, say 40 or 50 feet above the ground.

(4) The concentration of such a large flux of light in a single unit renders the lamp unsuitable for purposes of ordinary street illumination in the United States.

(5) The advantage of economical production of light is offset by reason of the necessity for frequent trimming with expensive carbons.

(6) The fumes and ash given out by the lamp, the unsteadiness of the light, and the objection to frequent trimming render it unfit for most cases of interior lighting.

33. Among the so-called silver flame arc lamps in this country the **luminous arc** or **magnetite arc** is the one most used. It has the same characteristics as the other flame lamps inasmuch as the light emanates almost entirely from the flame itself and not from the electrodes. It has the disadvantage common to all these types of lamps in that the fumes are given off by the burning electrodes, making the lamps unfit for interior illumination.

34. The **electrodes** consist of an upper copper plate and a lower metal tube containing oxide of iron. The appearance of the lamp is closely similar to that of all arc lamps. They are of the constant current type and especially designed to operate with high-tension direct current, rectified by means of a mercury vapor tube. A large number of cities and towns in the United States have installed them, and owing to the small consumption of energy, the simpler construction when compared to the old style open type of arc lamp, there is a large annual saving in favor of the magnetite lamp. This lamp is of the open type, and a comparison between the old style open carbon electrode lamp and this lamp shows a very much greater economy. In addition to the lesser efficiency the open arc must be trimmed every day, while the magnetite arc is only trimmed once in fifteen days. The open arc lamps require two carbons a day, and the magnetite arc uses one upper electrode and twenty-six lower electrodes per year.

FILAMENT OR INCANDESCENT LAMPS

36. The incandescent carbon filament lamp was invented by Thomas A. Edison in the early days of electricity, to take the place of the arc lamp where a small lamp was required,

and for many years only a slight improvement was made over the lamps commercially manufactured by Mr. Edison. These lamps consist of a carbon filament through which electricity is passed until the energy expended in the high resistance of the filament causes it to reach the point of incandescence. To prevent its burning itself out the filament is enclosed in a vacuum obtained by exhausting the air in a hermetically sealed glass globe.

36 *a*. Three years ago the graphitized carbon, commonly known as the Gem, lamp was introduced. This is virtually the treated carbon filament lamp subjected to an additional baking process at high temperature, which imparts to it a positive temperature coefficient, usually characteristic of metals. This lamp at 15 or 20 per cent higher efficiency has about the same life as the older carbon filament lamps, while possessing the same advantages of convenience, reliability, and low cost.

37. Within the last few years there have been brought out various improved types of incandescent lamps wherein the carbon filament is replaced by other material such as **tantalum, tungsten, osmium**, etc., and many of these lamps are now largely manufactured on a sound commercial basis, and though they have not yet replaced the carbon filament lamp, it seems certain that they will do so in the near future. Their development should be watched most closely, both by the general public and by solicitors, since as soon as they can be had in sufficient quantities and the price reaches a favorable point, their superiority will be very marked.

38. These lamps, generally speaking, are of higher efficiency, higher cost, and somewhat longer life. They give a somewhat whiter light, very close to daylight in color. The question of employment of these lamps as compared with the carbon filament lamps is determined largely by their first cost and cost per kilowatt-hour charged by the company.

39. The **carbon filament** is usually made from amorphous cellulose dissolved in chemicals until it has the consistency of thick jelly, which is squirted through a small hole, dried, baked in charcoal ovens, treated and placed in vacuum bulbs, and tested.

40. The lamps are most widely used with plain glass, *pear-shaped bulbs.* These are made in a great variety of

[illegible]

spherical reduction factor, the mean spherical candle [illegible] of the mean horizontal candle power. The va[illegible] [illegible] with the shape and arrangement of the fila[illegible] For the ordinary form of carb[illegible] lamps it ca[illegible]

sumed between 0.80 and 0.85; with tantalum lamps and other long straight filaments it is about 0.73.

44. The **rated watts per candle** of a lamp is its initial specific consumption. Sixteen-candle power carbon filament lamps are supplied by makers in three regular grades: 3.1, 3.5, and 4 watts per candle power. Carbon lamps of lower specific consumption than 3.1 watts per candle power are not to be recommended, because of their short life and inferior candle-power performance.

45. In working out the comparison of two different lamps to ascertain the **cost of light** for a certain number of hours, the following formula will be useful: —

$$C = I\left(\frac{t \times c}{T} + \frac{t \times p \times c'}{1000}\right),$$

wherein C is the total cost of light used in t hours; c, the cost of the lamp per candle power; T, the useful life of the lamp in hours; p, the initial specific consumption of the lamp in watts per candle power; c', the cost of energy per kilowatt-hour, and I the candle power. For general estimating work values of specific consumption, p, can be assumed as follows: carbon filament, 3 to 4.5 watts per candle power; tantalum filament, 2.2 to 3 watts per candle power; graphitized (often misleadingly called 'metalized') filament, 2.5 watts per candle power; tungsten filament, 1.25 watts per candle power; osmium filament, 1.5 watts per candle power; zirconium filament, 1 watt per candle power.

46. The **useful life of a lamp** should be carefully distinguished from actual life. Useful life means the number of hours the lamp burns before it drops to 80 per cent of its initial candle power, after which its efficiency is generally so poor that it should be discarded. **Actual life** means the number of hours the lamp will burn before the filament breaks. In general, the average useful life of an incandescent filament lamp may be taken as 800 hr. It is false economy to burn a lamp beyond its useful life. Another way to look at the useful life of a lamp is to consider it as the number of hours which will make the **average cost per candlepower-hour a minimum.** It can then be expressed by the following equation: —

$$T=\sqrt{\frac{2000\,c}{c'\times p'}},$$

wherein T is the useful life in hours; c, the cost of the lamp per initial candle power, and p', the increase in specific consumption in watts per candle power, which is assumed to be uniform; and c', the cost of electric energy per kilowatt-hour. For example, a 16-candle power lamp costing 16 cents, and increasing 1 watt per candle power in specific consumption during 500 hours where energy costs 10 cents per kilowatt-hour, would have a useful life of

$$T=\sqrt{\frac{2000\times 1}{10\times .002}}=316 \text{ hr.}$$

47. Cheap energy and dear lamps increase the useful hours when figured according to this reasoning.

48. Assuming a useful life of 800 hr. and a good steady voltage regulation on the system, the **consumption of a lamp which will make the total cost of lighting a minimum** can be determined by the following formula when the price charged per kilowatt-hour for energy is known; thus, the cost of light for t hours in cents is:—

$$C=\frac{t\times c}{800}+\frac{t\times p\times c'}{1000},$$

wherein t is the number of hours the light is used; c, the price of the lamp in cents; p, the initial consumption of the lamp in watts; and c' the cost of energy in cents per kilowatt-hour.

49. The Nernst Lamp.—The inventor of this lamp was Dr. Walther Nernst, of Göttingen, a well-known German scientist who has done much original research in connection with high-efficiency lamps. The Nernst lamp was first brought before the public in 1898.

50. The light-emitting element of the Nernst lamp is termed a **glower**. It consists of a porcelain-like thread about 1 inch in length and $\frac{1}{32}$ of an inch in diameter, and is composed of the oxides of certain rare earths such as thorium, cerium, and zirconium, mixed with suitable binding material.

It is remarkable that the composition of the glower is somewhat similar to the incandescent gas mantle.

51. The **glower** possesses many interesting features and **advantages**. The oxides of which it is composed are not liable to any further oxidization, and therefore it can be exposed to the atmosphere when incandescent instead of having to be enclosed in a glass bulb from which all oxygen has been extracted. It is also, for the same reason, capable of constantly withstanding a much higher temperature than the filament of the ordinary incandescent lamp is able to do; thus (see **23**) the economy of operation is greater. The **glowers** are **non-conductors when cold**, but become conductors when hot; hence they must be heated by an external source of heat before they will conduct the electricity sufficiently well to maintain themselves at a light-emitting temperature. In the earlier lamps the glowers were heated by a match or spirit flame until they became hot enough to conduct the current. It seems rather strange in these days to hear about an electric lamp that had to be lighted with a match. The match method was of course too clumsy and inconvenient, so an electric heating coil was provided and now forms an integral part of all lamps. This necessity for the preliminary heating of the glower is perhaps the one disadvantage of the Nernst lamp, for the operation takes from 15 to 30 seconds. The life of the glowers is about 800 hours and that of the heaters about 2500 hours. An automatic cut-out or switch is provided in each lamp to cut the heating coil out of use when the glower becomes incandescent, and thus energy is economized.

52. A peculiarity of the glower is that as the current traversing it is increased, the voltage across its terminals rises, at first rapidly and then more and more slowly to a maximum; it then drops off with increasing rapidity as the current through the glower and the resulting temperature continue to increase. Beyond the point of maximum voltage the rapid decrease in the resistance of the glower makes the current difficult to control without a **steadying resistance**, as such a conductor would quickly develop a short circuit and flash out. In the Nernst lamp the required steadying or ballasting is accomplished by means of a fine wire mounted *in a small glass tube* somewhat resembling a miniature in-

candescent lamp. With the aid of this ballast a very steady light is sustained. The life of the ballast is a long one, except when the voltage of the supply circuit fluctuates greatly.

53. The standard Nernst lamps are made for circuits of **voltages** varying from 200 to 240. The lamps are also made for 100- to 120-volt circuits, but do not operate as well as on the above-mentioned pressures. On 100- to 120-volt alternating current circuits it is usually preferable to employ the 200-volt lamp in conjunction with a small transformer. For successful operation it is advisable to use only lamps which are properly adjusted for the voltage of the circuit upon which they are to be used.

54. Nernst lamps can be obtained for use on direct current or alternating current circuits. In the latter case the greater the number of alternations, the longer the life of the glower. The **power factor** of the Nernst lamp is 100 per cent.

55. POWER CONSUMPTION OF NERNST AND ARC LAMPS

QUANTITY	NERNST LAMPS				ARC LAMPS	
	6 Glower	4 Glower	3 Glower	1 Glower	a. c. Multiple	d. c. Multiple
Volts	220	220	220	220	110	110
Watts	521	349	263	88	417	539
Mean spher. c. p.[1]	176.4	118	77.1	22.5	140	182
Mean hemispher. c. p.	297.2	189.1	124.5	36.3	167	239
Watts per mean spher. c. p.	2.95	3	3.4	3.92	3	2.96
Watts per mean hemispher. c. p.	1.76	1.84	2.11	2.43	2.50	2.25

56. After the arc lamp the Nernst lamp is the best artificial light for showing the natural or daylight **colors** of the materials it falls upon. The only deficiency, and this is but a trifling one, is that the pure whites are shown with a faint yellow tinge, and the blacks sometimes appear slightly rusty.

[1] *The arc lamps are fitted with opal inner and clear outside globes, and the Nernst lamps are fitted with sand-blasted globes.*

The strong blue of the arc is missing, and in its place is found a comfortable, rich yellow light which is pleasing to the eye. Thus from the color point of view the Nernst lamp is a very valuable one, especially in stores where colors have to be matched.

57. The Nernst belongs to the class of high-efficiency lamps, as the **power consumption**, compared with the light given, is only about half that of the ordinary incandescent lamp.

58. While the **Nernst lamp** properly belongs in the **class** of incandescent lamps, from the maintenance standpoint it is more akin to the arc, owing to its general structure; the three main structural parts of the Nernst, viz., the lamp, body holder, the globe, being analogous to the corresponding parts of the arc lamp. From this point of similarity alone it would seem evident that the **maintenance of arc and Nernst systems** is much the same. In the arc system the lamps are periodically inspected, globes and shades cleaned, and occasional faults and failures of the internal mechanism repaired. Likewise, in the Nernst system the requirements are the cleaning of the glassware, the replacing of burned-out holders, and the removal of an occasional ruptured ballast. The extra labor necessary for the subsequent repair of the Nernst holders may be counterbalanced by the extra time required in the arc system for more frequent inspection tours; the average life of the glowers is about ten times that of the carbons.

59. The work of **keeping Nernst lamps in order** does not necessitate the employment of labor which is more skilled than that required for lamp trimming. Any handy man will soon learn to do it, especially as the system of trimming is such that the actual repairs are not made in the lamp in position, but on a removable holder, which is taken to a convenient workshop or other center. The actual work of repairing is so simple that a boy or girl can soon be trained to do it.

63. Vapor Lamps. — In the mercury vapor type of lamp the light is produced by an electric discharge passing through mercury vapor contained in a glass tube. The **mercury vapor lamp** is made for either alternating or direct current circuits, both types being similar in appearance. The tube is made of clear glass with an electrode at each end, and con-

tains a small quantity of mercury. The electric curre through the mercury vapor excites it to incandescence ar produces light. The lamp is started by establishing metallic circuit through the mercury contained in the tul and then breaking the circuit, thus causing an arc whi renders the mercury vapor conducting and allows tl electricity to traverse the entire length of the tube. Tl lamp is usually built so that the tube can be tilted by mea of a chain. This causes a long stream of mercury to conne the electrodes, and on releasing the chain the tube sprin back, separates the mercury thread, and strikes the arc.

64. The lamp has a **specific consumption** of only 0.5 wa per candle power, and having a very low brightness and comparatively large radiating surface, it gives a **diffused lig** which is remarkable in that it casts practically no shadow The mercury vapor lamp would be an ideal illuminant were not for the total absence of red rays, which renders it usele wherever **color values** are to be preserved, and limits its u to factories, drafting rooms, studios, greenhouses, etc., whe color is either immaterial or the green is especially desired.

68. The Moore Tube is applicable to the lighting of lar areas, where a source of low intrinsic brilliancy and lar intensity is required. It may be used only upon alternatir current.

69. The **installation** in the average room or store consis of a continuous glass tube about 1¾ inches in diamete supported by simple fixtures on the walls or ceiling at abo the height of the picture molding, and therefore somewh above the direct line of vision. These tubes are put togeth on the premises of the buyer, in any shape desired and at ar length, varying from 40 to 200 feet.

70. The **necessary apparatus** for the Moore vacuum tub consists of two parts, the long glass tube and a small termin box securely enclosing both ends of the tube, containing potential raising transformer. The lamp is operated fro an alternating current circuit, and if a direct current circu only is available, a small motor generator set is usually in stalled.

71. The **advantages** of this light are claimed to be:—

1. Its very close resemblance to daylight (carbon dio *ide tube);*

2. The low brightness, resulting in less fatigue to the eye;
3. Cheap installation;
4. Greater economy than the carbon filament lamps;
5. The color of the light can be made any tint desired, from a close imitation of daylight to the special colors required for advertising and other purposes;
6. Since very little heat is given off by this type of lamp, it is claimed to be safer than any other illuminant.

72. The **cost** of an **installation** varies with its location, depending upon the shape and length of the tube. The intensity of the light required, the kind and number of fixtures and other local conditions are said to be such that the cost is less than that of a first-class incandescent lighting system. The **cost of operation** is considerably less than that of the incandescent lamp system; the exact consumption for a given amount depends upon the color desired and also on the length of the tube, but a Moore tube installed in the lobby of a well-known New York theater shows a consumption of less than two watts per candle power for 160 feet of tubing.

SHADES AND REFLECTORS

73. Shades and reflectors are quite different things. A **shade** is intended to add an ornamental appearance to the light, shade it from the eye, and at the same time to soften and diffuse it. A **reflector** is intended to direct the major portion of the light in the direction required. A reflector also assists in diffusing the light.

74. By the aid of carefully selected forms of reflectors light can be economized and better results obtained.

75. The average carbon filament lamp of 16 candle power will be found to give its rated candle power in a horizontal direction, assuming the lamp to be suspended vertically, but only 8 c. p. in a downward direction, and at an angle of about 45 degrees the candle power will be about 13. Since the maximum illumination is usually required in a downward direction for such purposes as store lighting, it is very essential that good reflectors be employed to overcome this unfavorable feature of the ordinary lamp. Many spe-

cially shaped lamp filaments and bulbs have been introduced with the object of attaining a more uniform illumination, but they do not seem to have attained much success, probably owing to the fact that purchasers prefer the ordinary lamp as they know how reliable it is, whereas there may be an element of uncertainty in a new form of lamp.

76. In order to attain a better downward illumination some lamps are partly silvered or provided with either a special **external or internal reflector.** Such devices add materially to the cost of the lamp, which makes the user retain it in service some time after it should have been scrapped. Practically the same effect can be obtained by separate reflectors which do not form an integral part of the lamp. By the use of proper reflectors 20 to 50 per cent [illegible] effective illumination may be obtained.

77. **Prismatic glass shades** and globes such as those known [illegible] trade as **Holophane**, which are designed along scientific [illegible] are often of great value as diffusers and concentrators [illegible]. In these devices the glass is cut so as to form a [illegible] of small prisms which break up and redirect the [illegible] in the direction required.

77a. [illegible] other forms of reflectors and globes, including [illegible] opal glass, have many desirable features, in [illegible] with diffusion and re-direction of light.

78. Lamps which are placed in such positions that they [illegible] are generally obscured or **frosted**. This [illegible] but at the same time cuts off a good deal [illegible]

79. In certain cases where the **downward illumination** of [illegible] a particular make of lamp is not good, it can be [illegible] by frosting the lower end. This is generally [illegible] lamps.

80. Lamps should be frosted or obscured by sand-[illegible] as coating the lamp with any [illegible] of a paint does not let as much light [illegible] producing the same appearance. [illegible] lamps is still even illumination [illegible] and deep shadows on the surface [illegible] by the aid of a device known as [illegible] **diffuser** in combination with an opal shade [illegible] consists of a circular disk of sheet

steel having concentric corrugations. It is enameled white on the reflecting surface, so that it reflects well, and the corrugations serve the purpose of breaking up and diffusing the light. The opal shade used under the arc should not be too dense, or the effect is not so good.

83. The concentric diffuser is made in the form of an **inverted cone**, having a very obtuse angle at its apex, which is towards the arc lamp it is placed above. Where a stronger downward light is required, another form known as the **inverted concentric diffuser** is employed, which is the reverse of the ordinary diffuser, being inclined downwards and thus appears more like a big saucer placed upside down above the arc lamp. This form of diffuser is more suitable for factory lighting, especially when the lamps are hung up rather high, to avoid overhead cranes, etc. When such a diffuser is employed, light that would otherwise be absorbed by a dark ceiling or lost through a glass roof is usefully reflected downwards.

84. During recent years what is known as the **light balancing selective diffuser ceiling** has been developed for the purpose of improving the lighting effects of arc lamps. It is really carrying out to a greater extent and in a more artistic fashion the principles upon which the concentric diffuser is based. This type of ceiling consists of an inverted saucer-shaped ring about 5 or 6 feet across with a cone in the center, the whole being constructed of pressed sheet steel. The arc lamp with an opal shade is placed at the apex, the mechanism of the lamp being concealed within the cone. This combination, sometimes called a **light-balancing cone**, brings about an appreciable steadiness in the lighting, and compensates for the wandering of the arc (that is, the tendency of the arc to burn sometimes at one side of the electrodes and sometimes at the other, for the electrodes do not always burn away regularly). Furthermore, the strong selective absorption of violet rays in the reflecting pigment used on the ceiling, in conjunction with the steadying of the light, produces a quality and whiteness equivalent to average daylight. By reflecting a good deal of the light which in the usual case would spread itself over the ceiling and side walls, the efficiency of the light at the level of the counters in stores is *greatly increased,* and allows of more latitude in the placing of

the lamps, which in turn permits of a more symmetrical arrangement of the lamps and wiring. The lamp is entirely hidden from view, and the apparent height of the studding is considerably increased over the effect resulting from hanging the lamps in the usual manner.

85 These diffuser ceilings are generally employed in conjunction with sheet metal ceilings, but are also adaptable to wood or plaster ceilings of various designs.

ELECTRIC LIGHTING

86 Every installation of lamps is a problem in itself and requires its own solution. Generally, illumination requires a **diffused light** similar to daylight, with no sharp shadows, nor dark corners. **Artistic illumination** requires color schemes, and oftentimes shadows and sharp contrasts are needed to bring out certain desired effects, which could never be obtained with diffused light.

87 **Diffused light** may be obtained with a source of low [illegible] such as vapor lamps. With other light sources [illegible] reflectors, and diffusers must be used.

88 [illegible] attention has been paid in the past to the [illegible] of illumination. First of all, the light should be on [illegible] should come from above. Where [illegible] lamps above the field of vision. [illegible] since light shining [illegible] renders them unfit for [illegible] the same source. [illegible] bright. Too [illegible] the eyes [illegible] if the contrast [illegible] best result in elec- [illegible] lamps in the [illegible] diffusion of illum- [illegible] of lower candle [illegible] the adaptability [illegible] that renders [illegible]

[illegible] lighting the [illegible] exclusively.

ıs the advantages of convenience, cleanliness, health-
ss, and economy. These advantages were dealt with
ction 2 (see index).

. The central station company should do all in its power
lucate its **customers** to **get** the **best economy** possible,
that means, of course, the best possible results for the
y. When installing the system, a little intelligent
e on wiring should be sought, and the convenience of
nstallation will be largely increased.

. For instance, in the case of a **hall lamp** it is very nice
able to light it from either downstairs or upstairs, so
any one coming in when the lamps are off can turn
on, go upstairs, and turn them out there, or *vice versa.*
n, in a **bedroom** the **switch** is usually placed just inside
loor; many people consider it more comfortable to get
bed before putting out the light, and for those who pre-
do this an additional switch, known as a "two-way
h," which also controls the light, can be placed at the
of the bed within easy reach. Such little details cost
small extra sum, which is a trifling thing compared with
omfort derived.

. The **porch lamp** is a very useful addition to the elec-
lly lighted home. It assists visitors to find the house
dark and is a great boon to any one leaving the brightly
ed house, as it enables them to see their way clearly.
number of the house should either be painted on the
or placed where the light can shine upon it. If there
piazza to the house, one or two lamps will enable the
r to sit out there and read in the summer evenings.

. **Gas chandeliers** can readily be **converted into electric**
res, and often they can be adapted for both gas and
ricity. In such cases there is no necessity for purchas-
ew fixtures. It would be well, however, as these fittings
to be taken down to be altered, to have them repolished
relacquered. If electric light only is used, they will
in bright for years, so that it is worth while to go to the
nse of repolishing.

. Many people have in their possession beautiful and
ic oil lamps which they are naturally unwilling to dis-
although preferring electric lighting. There is no ne-
y whatever for their parting with the lamp if they part

[illegible] transforming an oil lamp into an electric lamp is not small. There are very cheap fittings [illegible] that can be attached with ease to an oil lamp, taking the place of [illegible] burner. This little fitting, when [illegible] with a light flexible wire to the electric supply, will turn the [illegible] lamp [illegible] a thing of beauty and a joy [illegible] to be blamed for its previ[illegible] the smoked ceiling above it, [illegible] cleaning and filling the burner [illegible] was anything but a "joy [illegible]

37. There are several features in an installation that have an important bearing on the amount of the bills, a few of which [illegible] will be given here.

38. [illegible] switches [illegible] inside the doors, so [illegible] when the rooms are [illegible] features of electric lighting [illegible] the lamps may be turned out [illegible] gas without the [illegible] matches. It is very easy [illegible] electric light if the [illegible] careless people, however, [illegible] the ordinary lamps [illegible] waste occurs which [illegible] While the ordinary [illegible] may be pointed [illegible] be turned up [illegible] others, but are [illegible] hall when a [illegible]

39 [illegible] switches: there [illegible] or more to [illegible] lamps, so [illegible]

[illegible] switches placed [illegible] switches fitted [illegible] in such [illegible] them out, [illegible] remain [illegible] reached

closely together with several lamps under one shade, should be avoided, as such fittings are the least economical of all, wasting quite 50 per cent of the light from the lamps. **Lamps hanging in a vertical position** are more efficient and last longer than those placed horizontally or at an angle. Some of the newer lamps, which are very efficient, will only light properly without becoming damaged in a vertical position, so for this reason, also, the lamps should be placed so as to hang vertically. New lamps can then be put on the fittings whenever desired without the necessity for alterations.

102. In the case of cellar lamps it is advisable to place a **pilot lamp** outside the cellar door or in some other prominent position. A pilot lamp indicates when other lamps controlled by the same switch are also lighted. People often come up from a cellar with hands full, unable to turn the switch off at the time, and consequently forget about it; if the cellar is not often visited, there is a chance of the lamps remaining lighted for some time; while, on the other hand, if a pilot lamp were installed, attention would be drawn at once to the fact that the cellar lamps were still lighted.

103. In a drawing-room or parlor it is very often useful to have a good lamp that can be placed in a convenient position for the benefit of any one who is reading or writing. A **floor or table lamp** will be quite sufficient to furnish light for one or two persons, and the expense of burning enough light for the whole room will be avoided.

104. The **position of the floor or wall plug** for these lamps must be chosen with care so that the flexible connecting wires shall not trail about the floor.

105. The **lighting of servants' bedrooms** is a debatable point, as it encourages reading there and consequent long-hour burning. Servants are also apt to learn a little electrical engineering, just sufficient to change the low for high candle-power lamps from other parts of the house. Still, the fire risk is greatly reduced if electric light is installed in these rooms, and therefore it may be wise to do so on this account. In some houses the lamps in the servants' bedrooms are so wired that they can be controlled by a switch in the dressing room or similar place, and the consumer can extinguish their lamps when he goes to bed himself. Of course, all the lamps in the house can be turned off at the

main switch on retiring each night, just as some people do with gas; but as there is no danger of leakage, with electricity such a step in the electrically lighted house deprives every one in it of the valuable feature of electric light; which is, that it can be obtained immediately at any moment of the day or night by merely closing a switch.

106. If the **main switch** is **opened each night**, there is the objection that some one in the house may turn on a switch, and as the lamps will not light up, forget to turn it off again; the lamp controlled by that switch will light up and perhaps consume energy for several hours before it is discovered. Taking everything into consideration, it is undoubtedly the best way never to open the main switch except in the case of alterations or repairs. If care is taken to see that no more lamps are used in a room than are actually required, and that the number of lamps burning at one time in the whole house is a minimum, and also that the lamps are always switched out on leaving a room, it will be found that the electric bill will compare very favorably indeed with gas. When a consumer complains that his electric light bill is [illegible] it is nearly certain that he is either using cheap lamps, [illegible] using an extravagant amount of light, [illegible] too high, shading his lamps too much, or [illegible] of these things together. Under [illegible] the best plan is to take the matter up [illegible] station manager, who will be only too [illegible] any advice needed to correct the faults [illegible] the operation thereof.

107. The Lighting of Factories. — For the **general illu**[illegible] lamps should be used, especially [illegible] and where lamps have to be placed [illegible] other machinery. Unless the [illegible] the arc lamps should be [illegible] similar diffusers, so that the [illegible] light can be reflected down-[illegible]

108. [illegible] **ceilings are low** inverted arc lamps should [illegible] by reflection, all the [illegible] thence reflected on the [illegible] soft, diffused light [illegible]

109. In addition to the arc lighting at least one **incandescent lamp** should be provided **for each machine**, preferably with a switch holder, protected with a wire cage and enameled iron reflector. Incandescent electric lamps afford the workman a good light that he can place close to his work, a light that is unaffected by vibration or drafts, thus insuring the turning out of better work. The atmosphere is also more healthy, making the work people more energetic, a point that is often overlooked by the owner.

110. A substantially made **flexible cord** should be employed for the lamps in use on the machines, as they are subjected to rough handling at times. It is well to adopt some of the adjustable lamp arms now on the market for holding lamps in any position, as such devices generally secure better results than when the workman is allowed to hold the lamp in the required position by twisting the flexible cord around any convenient part of the machine or tying it where he wants it with string or wire.

111. The **mercury vapor lamps** may often be employed to advantage for **general lighting** where the judgment of a color is not a matter of great importance, as it gives a very soft, restful light that is pleasing to the eye and throws no deep shadows on the work. This lamp has been used with great satisfaction in drafting offices, and is a very economical light so far as energy goes. The only objection to it is that red tints lose their natural appearance, the light being deficient in red rays. In some of the newer lamps, however, this is corrected by the addition of an auxiliary lamp rich in red rays, or by the use of a red fluorescent reflector behind the tube.

112. During the short winter days or when, owing to unfavorable climatic conditions, the sun is not able to be of use as regards the making of proper prints, no decrease in the usual output of the blue printing department need take place, provided an **electric blue printing** equipment has been installed. When sufficient daylight is available it may be used as formerly, but upon the failure of the proper intensity of the solar rays work need not be halted, for here the electric arc lamp may be brought forward to continue the business now stopped by the failure of the sun. Thus, *the arc lamp may be* used to help out when the sun become

obscured, or it may be depended upon for doing the entire work, as, for instance, where in cities, by reason of the tall buildings, the sun is seldom available for use in this connection. Again, the use of arc lamps for printing greatly reduces the time that need be lost between the finishing of the tracings and the completion of the print, since the lamps can be thrown on at any time and tracings may be rushed to the frames as soon as dry.

115. The Lighting of Stores. — The lighting of stores may be divided into two main heads: —

(*a*) The general illumination of the interior;

(*b*) The lighting of the show window and the exterior. The latter is not so much a question of light as it is of light advertising.

116. In regard to the **general illumination** of the interior, ample well-diffused light of good color is required, especially in those stores where the purchasers have to match colors. Electric light, more than any other artificial illuminant, can be best adapted to meet the requirements of the storekeeper.

117. A point that should be carefully attended to by the central station in advising the lay-out of an electric light **installation for a store** that has previously been using gas, is to see and also to insist that for the first three months or so the storekeeper only gets light which is comparable with his former gas illumination; this will make him satisfied with his bills. Afterwards, when he sees how much better lighted other stores are and wishes to increase his own lighting, as he is sure to do, he will appreciate the fact that his electric light bills are greater in amount than his former gas bill, not because electric energy is an expensive luxury, as some misinformed people erroneously say and think, but because he is using so much more light. A great deal of trouble has been caused to central station managers by the general dissatisfaction as regards cost of electric energy, caused by the complaints of new consumers who, having gone into electric lighting with a lavish hand, getting three or [illegible] the light they previously obtained from gas, are [illegible] when they find the bills are greater. A little [illegible] at the start would eliminate this source of [illegible]

118. No matter what the **cost of electric light** may be, the storekeeper will find it a good investment, and one that he is practically compelled to accept, since the patrons of electrically lighted stores find that the quality of the stock sold there is high, that the goods show to better advantage, and that there is no trouble in matching colors. For a better quality of light than gas provides, the bills will be about the same, and the up-to-date storekeeper finds that it pays to spend a little money on electric lighting, as he can make a better display, have a fine advertisement, and realizes that he is paying not for light alone, but for an indispensable convenience.

119. Electric **store-window lighting** is fast getting to be an unassailable stronghold, almost regardless of the price charged for energy, in the competition with gas interests, the strongest point of vantage being the possibility of concealed lighting.

120. There is a **mistake in store-window lighting** which is frequently made, probably due partly to the ignorance of the storekeeper or the wiring contractor, or perhaps both, in that the light employed often shines right into the eyes of the on-looker, which is not only annoying, but also prevents the goods displayed being seen to their best advantage.

Show-window lighting may be divided into two main classes according to the purpose they are mainly intended to serve: first, that in which the object is to display the goods, and secondly, that in which the object is to draw the attention of those passing at a distance to the window. It will be noticed in well-lighted stores, that is, well lighted from the illuminating engineering point of view, even where a great display of light is made outside by the aid of luminous or flame arc lamps, that, in addition, the show window itself is taken care of by independent concealed lamps, generally placed at the borders or tops of the windows, full advantage being taken of reflecting mirror and patent systems, such as "Linolite." These facts are, of course, well known to electrical engineers, the important thing is to keep hammering them into the storekeepers.

121. While great use has been made by the storekeepers of **outside show-window lamps** with the name painted on the *side facing the street,* comparatively little has been done in

115

... letters are very much more effec-
... standing out much more prominently ... electric signs are placed flat against a ... should be used, as they show more ...s.

... does the sign itself cost? The ... naturally depends upon the number ... used, and the number of lamps ... The price for a single letter ... number of lamps required to ... an average from $6 to $12 a ... the letters. Table 131 will ... fairly accurate calculation as to ... any sign can be obtained.

116

... Approximate Cost of Electric Signs[1]

... Number of Lamps per Letter		Price per Letter
...	Grooved	Dollars
	4	6.20
	[illegible]	6.80
	[illegible]	7.00
	8	7.60
	8	7.90
	8	8.20
	10	9.40
	10	10.70
	12	12.80

.17.

... letters would be about 20 pe... style of letter, such as ... would be from 2.5 per ce... indicated in the table ... electric lettering ... the cost of ... writing ...

... Standard ...

hen these figures work out at a great
m that many people imagine must be
gn. The same thing also applies to the
is far less formidable than is generally
nple, if a sign contains 4-c.p. lamps, it
nake up a kilowatt of capacity, and if it
, it takes approximately eighty to make
multiply its capacity in kilowatts by the
ing which the sign will burn each night,
mption of energy in kilowatt-hours is
wing the rate charged for energy, it is
umber of kilowatt-hours by the rate, and
ost of signs containing various numbers

ING AN ELECTRIC SIGN PER HOUR — THE
PER KILOWATT-HOUR, USING 4- OR 2-C.P.

(Average Efficiency)

-C.P. LAMPS. COST PER HOUR	2-C.P. LAMPS. COST PER HOUR
Cents	Cents
5	3
10	6
15	9
20	12
30	18
40	24

nber of hours burning per month, 75 to

burning a sign is compared with cost of
paper, the comparison will be found to
gn, especially as it points out the exact
and attracts people to it.

Public Halls and Churches. — Prior to
tion of illuminating gas it was the cus-
ior of buildings with torches, candles, or
cy of these illuminants was relatively so
at distress the eye, and their number

the installation of electric signs proper, that is to say, signs which can be read at some little distance.

122. Since the lighting of electric signs for long hours is, of course, very profitable to the central station, everything possible should be done to encourage it. In wiring the stores switches should be so arranged as to be accessible from the outside, so that the sign and show-window lamps may be turned on and off without the necessity of unlocking and entering the store. In some towns a night watchman is employed by the storekeepers, who, in addition to his other duties, switches the light on and off at given hours. As an alternative, it may be advisable for the central station to arrange to do this work. In the latter event, however, care must be taken to keep accurate time, as the merchants will naturally object if their lamps are burned beyond the stipulated period, when they are paying for the energy consumed on a meter basis. There are now a number of reliable time switches on the market that can be employed for the purpose of turning the light on and off.

123. The time switch consists of two main parts — a clock and an electric switch. The clock is so adjusted that at any required time it trips a catch which causes the switch to close, thus lighting the lamps; after a certain time has elapsed it actuates another catch which causes the switch to open, thus turning off the light. The time switch takes the place of a watchman or care-taker in turning off the light at a given time. The work is done exactly on time, avoiding waste of energy that occurs when the watchman happens to be late, and the loss of advertising value when he is too early.

124. The cheaper forms of these time switches which require winding each day can be obtained for $6 and upward. A good reliable time switch must necessarily be expensive since an accurate clock forms part of the device. The more expensive types of time switch can be so arranged as to switch on and off daily, or daily except Sundays and early closing days, or twice daily at certain hours, say, first early in the evening to catch the eye of the home-going crowds and later on to arrest the attention of people going to and returning from places of amusement. A merchant, when persuaded to adopt one of these means of turning his lamps on *and off,* will always burn them longer hours than if he had

to attend to it personally. If a number of the stores use long-hour light-advertising in this way, it will not be a great while before the remainder follow suit. It should be impressed on storekeepers that a bright light always attracts attention, and, therefore, the lighting of their signs and show windows is to be regarded as an advertisement rather than as a mere matter of getting sufficient light.

125. There are many **kinds of electric signs**; some flash out and in, and others seem to be written with an invisible hand. Occasionally the inscriptions appear sentence by sentence or word by word. Signs in the form of emblems, trademarks, flags, eagles, etc., studded with sockets; live borders for signs, such as crawling serpents, jumping grasshoppers, or rabbits. But the most popular form of electric sign gives a steady illumination with white or colored lamps; the letters may be interchangeable so as to alter the reading occasionally if desired.

126. An electric sign should be considered as an **advertising investment**, and if the impression it makes is not a good one, the money invested in it is worse than thrown away. It should lend a distinguishing air of quality to a shop, and it is this element which gives it its greatest value. While a sign will designate a place of business, and perhaps the nature of that business, a large part of its value lies in the impression it makes. Hence only the best and most permanent types of sign should be adopted, no matter how small they must be to meet the price the customer can afford to pay for it.

127. Some of the **essentials of a good sign** are that it should be made of the very best materials, carefully put together and simple in construction, so that it may be very durable. It must be waterproof and have a surface of preferably enameled metal that will not fade or lose its color. Mechanical arrangements for its suspension must be such that it is rigidly and safely supported, not only actually but in appearance.

128. Turning from such generalities as the preceding with the conviction that electric signs are of great value as advertising mediums, it will be well to consider more in detail what the **actual cost** of this **electric advertising** will be.

129. The **reading on a sign** should be made as brief as *possible, and large* electric letters should be employed,

spaced well apart. Raised letters are very much more effective than flush letters, standing out much more prominently both day and night. When signs are placed flat against a building, grooved letters should be used, as they show more plainly and need fewer lamps.

130. First of all, what does the sign itself cost? The **price of an electric sign** naturally depends upon the number and size of the letters required, and the number of lamps necessary to illuminate them. The price for a single letter illuminated by the minimum number of lamps required to give a good effect, range on an average from $6 to $12 a year according to the height of the letters. Table **131** will enable the reader to make a fairly accurate calculation as to the price for which a satisfactory sign can be obtained.

131. Cost of Electric Signs[1]

Height of Letters in Inches	Average Number of Lamps per Letter		Price per Letter
	Raised	Grooved	Dollars
10	6	4	6.20
12	8	6	6.80
14	8	6	7.00
16	10	8	7.60
18	10	8	7.90
20	10	8	8.20
24	12	10	9.40
30	14	10	10.70
36	16	12	12.80

132. Signs with **flush letters** would be about 20 per cent less expensive, while any special style of letter, such as the old English or pointed block, would be from 2.5 per cent to 20 per cent higher. The prices indicated in the table do not, of course, include extras such as non-electric lettering or special ornamentation. Neither do they include the cost of materials for hanging the sign, or of wiring for writing or spelling

[1] *The letters supplied* at these prices would be of the standard block style, made *of metal on a full metal background*, Japan enameled.

flashers. But even then these figures work out at a great deal less than the sum that many people imagine must be spent for an electric sign. The same thing also applies to the cost of operation — it is far less formidable than is generally supposed. For example, if a sign contains 4-c.p. lamps, it takes fifty lamps to make up a kilowatt of capacity, and if it contains 2-c.p. lamps, it takes approximately eighty to make up a kilowatt. Now multiply its capacity in kilowatts by the number of hours during which the sign will burn each night, and the nightly consumption of energy in kilowatt-hours is thus obtained. Knowing the rate charged for energy, it is easy to multiply the number of kilowatt-hours by the rate, and thus get the nightly cost of signs containing various numbers of lamps.

133. COST OF OPERATING AN ELECTRIC SIGN PER HOUR — THE RATE IS 10 CT. PER KILOWATT-HOUR, USING 4- OR 2-C.P. LAMPS

(Average Efficiency)

NUMBER OF LAMPS IN SIGN	4-C.P. LAMPS. COST PER HOUR	2-C.P. LAMPS. COST PER HOUR
	Cents	Cents
25	5	3
50	10	6
75	15	9
100	20	12
150	30	18
200	40	24

134. Average number of hours burning per month, 75 to 150 hours.

135. If the cost of burning a sign is compared with cost of advertising in a local paper, the comparison will be found to be in favor of the sign, especially as it points out the exact position of the store and attracts people to it.

136. Lighting of Public Halls and Churches. — Prior to the general introduction of illuminating gas it was the custom to light the interior of buildings with torches, candles, or lamps. The brilliancy of these illuminants was relatively so *low that they did not* distress the eye, and their number

was so small that there was but little danger of overstimulating the eye by glare. Thus, the altars of cathedrals, in full view of the assembled congregations, glittered with many tapers; but the retinal stimulus was agreeable rather than excessive.

137. When, however, gas became available for lighting public halls, and particularly when high-efficiency arc and incandescent lamps came into use, the habit, many centuries old, of hanging the **illuminating sources in full view of an audience** became a pernicious custom. Although the plan is decried by experts, yet it persists even to-day, and people all too frequently sit in a public hall trying both to see and not to see at the same time.

138. A 100-c.p. lamp enclosed in a translucent globe a foot in diameter will allow the eye to rest upon it without fatigue, whereas the same total candle power in a naked filament might at short range be painful and even dangerous to look at. The ideal **test for all lighting** is that sufficient illumination should be provided in all parts of a room for easy reading of printed matter, and at the same time every source of illumination should be concealed from direct view, like the footlights of a theater. When it is not feasible to conceal the lamps, they should be enclosed in or covered by diffusing globes or reflectors, so that they may be well distributed and the intrinsic brilliancy reduced as viewed by the observer.

139. Undoubtedly the **best results** in the **lighting of large halls** are obtained by the means of arc lamps placed above a false ceiling made of translucent glass. The color of the light produced by arc lamps is the nearest approach to daylight made by any artificial light, and the transmission of the light through the glass ceiling diffuses it well, obviating the objectionable dark shadows often caused by improperly placed lamps of such great candle power as the arc.

140. The method referred to, while being the best that is known at present, has the disadvantage that it is the most costly, requiring special construction of the hall, which is difficult to arrange for in existing buildings, and necessitating the consumption of much energy, as the lamps are placed so high above the floor.

141. The modern tendency is rather toward the ***elimination of heavy, elaborate electroliers***, such as were in vogue at

one time, the fact that it is light and not ornament that is wanted being more appreciated now. · These heavy fixtures often interfered with the proper distribution of the light. The **finish of modern fittings** is usually an oxidized or black surface, as this is not obtrusive and is less trouble to keep clean than brass, though in buildings where electric light is used exclusively, polished brass work does not require one tithe of the attention necessary where open-flame illuminants are used. There is a misconception prevalent that it is necessary to support electroliers in churches and other public buildings on heavy chains. There is no real need of this at all, as a wire cable support is as strong, if not stronger, than chains, and very much less obtrusive. The only thing that has to be taken into account when considering the advisability of hanging by chains is whether or not the chains should be used as an ornament to harmonize with the general decorative scheme.

142. It is better to **avoid the use of arc lamps** if it is desirable to economize in light by hanging the lamps comparatively low, as it is difficult properly to diffuse light given by such powerful sources under such circumstances. In this case it is preferable to use glower and metallic filament incandescent lamps, enclosing them in suitable globes or shades. **Glower lamps** should not be used alone in a public building without a fair number of other types of lamps, as they take from ten to twenty seconds to light up. This, in the interests of public safety, is too long after the switch has been turned on, for the delay would be serious in the case of panic. As the glower lamp is very economical in the consumption of energy, and gives a high candle power, it is of course very useful, and may be employed to advantage in conjunction with other lamps, as suggested above.

143. Owing to the introduction of modern **metallic filament lamps**, with efficiencies very similar to those of arc lamps, it is well to arrange the lamp holders of all electroliers and brackets so that they will hold the lamps in a downward vertical position, as this is the position that will suit all types of lamps, permitting the use of any new lamp that may be placed on the market subsequent to the wiring of the building. Where **lamps** are **grouped together** it is advisable to have the groups arranged to contain even numbers, as many of the new

lamps can only be made for low voltages and will therefore have to be used in pairs, each lamp of a pair being in series with the other. The alteration required in the wiring of a fitting to enable lamps to be used in this way is very slight, especially if the fitting is made for an even number of lamps. Special attention should be paid to the lighting of the platform or stage of a hall, as it is of great advantage to the spectators if they can easily see the speakers and actors.

144. It is advisable to arrange that each side of the **hall** and the **stage** should be **wired** on a separate circuit, so that in the case of an accident to one circuit the whole place would not then be plunged into darkness. The division of the hall into two sections is also an accommodation to the electrical supply company, as it enables them to keep up a steady pressure. Ample provision should be made for **temporary connections** for additional lighting at both sides of the platform or stage, as this considerably facilitates the work on the occasion of any special shows, and prevents damage to existing wiring. Conveniently located wall plugs along the sides of the building are of great service at any exhibitions, shows, sales, etc., that may be held in the hall. In the rear of the hall provision should be made for connecting up **cinematograph lanterns** which are so often exhibited in public halls to-day. These lanterns take a good deal of current, and therefore should be provided with a substantial connecting box with special fuses.

145. The main **switchboards** should be placed at the rear of the platform in locked cases with glass fronts, so that mischievous persons cannot tamper with the switches. In case of accident the breaking of the glass would permit of immediately getting access to the switches to turn all the lamps on. Another switchboard should also be placed at the main entrance to control a few lamps only, so that in case of need sufficient light could be switched on from that end of the hall.

146. In all public halls, whether lighted by electricity or gas, small oil lamps should be placed above the exits for safety, not that dependence cannot be placed upon electricity or gas, but both come into the building by one pipe or cable, and there is always the remote possibility that that pipe or cable may be severed by some unforeseen accident.

147. The **illumination of a large building** is not an easy matter, and requires more experience than that possessed by an architect or wiring contractor, and should therefore be put into the hands of a consulting electrical engineer accustomed to deal with illuminating problems, as it is a very important matter, not only in regard to the cost of electric energy consumed, but in regard to the cost of the installation and the quality and distribution of the light furnished.

148. If the wiring arrangements are properly designed and the lamps carefully grouped, the energy consumption can be greatly economized, as no more lamps need be turned on at a time than are actually required. In churches it is common practice to turn out a number of lamps during the sermon because they are not then needed and it enables the congregation to devote more attention to the preacher, as the eye does not wander in a dimly lighted place as easily as in a well-lighted one.

ESTIMATION OF ILLUMINATION

149. To estimate the illumination required, the following **rule** was recommended a good many years ago by Sir William Preece: "One 16-candle-power lamp eight feet above the floor, for every eight feet square or 64 square feet." This rule for ordinary incandescent lamps works out to one watt per square foot; the color of the ceiling and walls may allow this to be reduced to half a watt, or may necessitate an increase to more than two watts per square foot. From this it will be gathered that no hard-and-fast rules can be given. Another method sometimes adopted is to allow twenty candle power for every hundred square feet of floor space, the lamps being hung about 7.5 feet from the floor. Table **150** will give an approximate idea of the number of watts per square foot adopted in general practice for good lighting by arc and Nernst lamps.

For incandescent lamps the table is approximately true if the values are multiplied by two. The number of lamps required for any given service equals the factor found in Table **150** *multiplied by the area in square feet and divided by the watts consumption* of the lamp.

150. Watts per Square Foot for Lighting with Nernst and Enclosed Arc Lamps. Power based on Terminal Watts

Location	Average Watts per Sq. Ft.	Max. and Min. Watts per Sq. Ft.
Machine Shops (high roofs; no belts; *i.e.* electric-driven machinery)	0.75	0.5 to 1
Machine Shops (low roofs; belts and other obstructions)	1	0.75 to 1.25
Hardware and Shoe Stores	0.75	0.5 to 1
Department Stores handling light materials and bric-a-brac	1	0.75 to 1.25
Department Stores handling colored materials	1.25	1 to 1.50
Mill Lighting, plain white goods	1.10	0.90 to 1.30
Mill Lighting, colored goods and high looms	1.30	1.10 to 1.50
General Office Work	1.50	1.25 to 1.75
Drafting Rooms	1.75	1.50 to 2.50
House Lighting:		
Reception Rooms	0.8	0.5 to 1
Dining Rooms	0.6	0.4 to 0.8
Bedrooms	0.3	0.2 to 0.5
Churches and Lecture Halls	1	0.8 to 1.2

151. While the method of expressing the intensity of illumination in watts per square foot of floor area is a good one when dealing with lamps of high candle power, it may be more conveniently given in candle power per square foot for incandescent lighting.

A fairly safe rule for private house lighting is to allow two and a half 8-c.p. lamps (20-c.p. in all) for every 100 square feet of floor space when the lamps are suspended not more than 7 feet 6 inches from the floor. Bedrooms and less important rooms do not need such good illumination, one 16-c.p. or one 20-c.p. lamp usually being sufficient; 3- and 5-c.p. lamps will serve for lavatories, passages, and cupboards. As the bases of the lamps are all of the standard size, the lamps can be changed if necessary for those of larger or smaller candle power. Table **152**, due to Grawinkel and Strecker, is calculated on the latter basis.

152. Illumination for Different Classes of Service

Service	C.P. per Sq. Ft.
Dwelling House:	
Reception Rooms	0.3 to 0.4
Dining Rooms	0.25 to 0.3
Bedrooms	0.12 to 0.17
Passages, etc.	0.1 to 0.16
Offices:	
Principal Rooms	0.4 to 0.5
Less Important Rooms	0.16 to 0.2
Private Offices	0.125 to 0.25
Business Premises:	
Stores and Showrooms	0.3 to 0.6
Office and Storerooms	0.16 to 0.2
Store Windows	1 to 2 16-c.p. lamps per foot width
Hotels:	
Banqueting Rooms	0.75 to 1.1
Public Rooms	0.4 to 0.6
Best Bedrooms	0.25 to 0.3
Ordinary Bedrooms	0.16 to 0.25
Passages, etc.	0.08 to 0.12
Kitchens, etc.	0.1 to 0.16
Factories:	
For General Lighting	0.25 to 0.3
For Each Machine	at least 1 16-c.p. lamp

153. The only proper way to **estimate illumination** is on the basis of **foot-candles** required for a given result. If the foot-candles required for a given class of service are known, lamps can be installed in such a manner as to give the desired result. In a calculation of this kind there are so many variables that no fixed rule can be given. The same result may be obtained with various numbers of lamps of various candlepowers by changing the grouping, utilizing diffusers, reflectors, and wall surfaces. Having a lamp of known candlepower and distribution, the illumination of any point at a known distance can be calculated by the rule given in **9**. Values of illumination for different kinds of service sanctioned by good practice are given in Table **155**.

154. Data on Successful Arc Lighting Installations in Operation. (Westinghouse Elec. and Mfg. Co.)

	Clothing Store	Weaving Room	Erecting Room	Machine Shop	Drafting Room	Drafting Room	Drafting Room
No. of sq. ft. in place lighted	4000	14,400	281,600	42,250	6275	6275	5691
Number of lamps used	12	50	200	42	27	35	24
Sq. ft. lighted per lamp	333	288	1408	1006	232	179	237
Sq. ft. lighted per ampere	55.6	88.6	227	162.2	30.9	35.8	59.2
Terminal watts used per sq. ft.	1.29	1.24	0.53	0.74	2.02	2.04	2.02
Kw. at terminals, entire installation	5.16	17.85	148.80	31.25	12.69	12.78	11.52
Kw. at arc, entire installation	4.62	13	99.2	20.8	12	12.6	7.68
Circuit	A. C. Mult.	D. C. Mult.	D. C. Mult.	D. C. Mult.	A. C. Ser.	D. C. Ser.	D. C. Mult.
Volts, terminal	104	110	120	120	76	73	120
Volts, arc	72	80	80	80	72	72	80
Amperes	6	3.25	6.2	6.2	7.5	5	4
Actual watts per lamp	430	357	744	744	470	365	480
Reflector used	Diffuser	Diffuser	Mirror	Mirror	Inv. Ceil.	Diffuser	Diffuser
Height of arc from floor, feet	9.5	12 to 15	46	47	9	9	15
Distance between lamps, feet	14 to 18	24 Approx.	32 to 38	30.75	15	12 to 25	12 to 25
Power factor of lamp at terminals	0.69				0.82		
Height and style of ceiling	12 Steel-white	Saw-tooth roof	Trussed	Trussed	12 Board white	12 Board white	Trussed

. Required Illumination for Various Classes of Service

Service	Foot-candles	Service	Foot-candles
mbly Rooms	0.5 to 1.5	Postal Service	2 to 4
litoriums, general	1 to 3	Public Spaces	0.5 to 1.5
Rooms	2 to 3	Reading, clear print	1 to 1.5
kkeeping	3 to 5	Reading, newspaper	2 to 2.5
rches, general	3 to 4	Residences, general	1 to 2
ridors	0.5 to 1.5	Stores, clothing	4 to 7
ks	2 to 5	Stores, display of dark goods	5 to 10
fting	5 to 10		
raving	5 to 10	Stores, general	2 to 5
rary, general	1 to 2	Theaters, general	1 to 3
rary reading table	3 to 4		

156. Illumination with Mercury Vapor Lamps

Service	Length of Tube in Inches	Candle-power[1]	Elevation in Feet	Floor Area per Lamp in Sq. Ft.
ndry	21	300	10 to 15	800 to 1000
ndry	45	700	20 to 25	2000 to 2500
hine Shop	21	300	10 to 15	375 to 600
ting Work	45	700	20 to 30	1000 to 1500
fting	21	300	15	150 to 250
fting	45	700	20	250 to 500
eral Office	21	300	10 to 15	300 to 500
eral Office	45	700	20 to 25	500 to 1000
gh Work	21	300	10 to 15	1000 to 1200
gh Work	45	700	20 to 25	2500 to 3000

[1] Mean hemispherical with reflectors.

157. Approximate Equivalent Illuminating Power of Various Kinds of Lamps

Nernst	Arc	Incandescent	Gas
One 6-glower at 528 watts	One 7½ amp. Mult. - Enc. A. C.	Twenty 16-c.p.	——
One 4-glower 352 watts	One 6-amp. Mult. - Enc. A. C.	Thirteen 16-c.p.	——
One 3-glower 264 watts	——	Nine and one half 16-c.p.	One 4-burner gas arc
One 2-glower 176 watts	——	Six 16-c.p.	——
One 1-glower 88 watts	——	Three 16-c.p.	One single mantle burner

158. Hours of Lighting

Hours of Lighting	Period of the Year during which Light is required at these Hours	Total Number of Hours of Lighting per Annum
6 A.M. till daylight		215
Dusk till 5 P.M.	Oct. 30 to Jan. 18	50
Dusk till 6 P.M.	Sept. 21 to March 9	222
Dusk till 6.30 P.M.	Sept. 4 to April 7	331
Dusk till 7 P.M.	Aug. 15 to May 6	550
Dusk till 7.30 P.M.	July 14 to June 11	720
Dusk till 8 P.M.	All the year	755
Dusk till 8.30 P.M.	All the year	900
Dusk till 9 P.M.	All the year	1090
Dusk till 10 P.M.	All the year	1455
Dusk till 11 P.M.	All the year	1820
Dusk till midnight	All the year	2185
Dusk till 2.15 A.M.	All the year	3000

Eight hours a day for 300 days amounts to 2400 hours per annum.
Nine hours a day for 300 days amounts to 2700 hours per annum.
Ten hours a day for 300 days amount to 3000 hours per annum.

year less 52 Sundays and 13 holidays, say 300 days, amounts to
:oo hours per annum.
year less 52 Sundays, say 313 days, amounts to 7512 hours per
ınum.
year of 365 days amounts to 8760 hours per annum.

COST OF ELECTRIC LIGHTING

9. Like a great many other things, this very largely nds upon the tastes and requirements of the house- er. If his **house** is already equipped with gas through- it may be wiser only to equip the living rooms with elec- :y at first, as then the initial outlay will not be so great, ıt the same time will prove a very good investment owing ıe saving of decorations and in cleaning. In this way y of the advantages of electric lighting can be enjoyed out much expenditure. In addition to the comfort it ;, it adds zest to the entertainment of visitors, who ap- :ate the cheeriness of this up-to-date illuminant. There) doubt but that, after experiencing the comfort and enience of electric lighting in the living rooms, its use be extended to other parts of the house.

HE COST OF INSTALLING ELECTRIC LIGHT

0. **In stores** it is usually cheaper pro rata than in resi- es, as the runs are generally shorter and the grouping e lamps closer. In wiring for the larger lamps the item bor is about the same, the only increase in cost being of the cables. In modern systems of lighting electro- are dispensed with, thus cutting out an item which in e wiring often amounts to a considerable sum. The method of wiring stores is by the conduit system, which :ctrically continuous, and is the best way of protecting wires from damage.

1. In **making estimates** on house wiring it is customary, ıe purpose of comparison, to reduce the cost to a basis much per outlet, each outlet supplying a lamp or group nps. The term includes wall plug outlets and sometimes *ontrolling switch outlets*. Table **162** gives an idea of

the cost per outlet for different systems of wiring. The figures are useful rather as a means of comparing one syste with another than as actual costs, for the cost of materi and labor varies in different parts of the country.

162. Cost of House Wiring

Approximate cost per outlet, single lamp wiring, inside buildings
(Based on a table prepared by C. L. Falconar)

System	Material	Labor	Tota
Iron gas pipe	$3.25	$3.15	$6.[illegible]
Screwed solid drawn tubing	3.40	2.50	5.[illegible]
Armored cables	2.25	2	4.[illegible]
Ordinary screw socket joint conduit	2.05	2.05	4.[illegible]
Painted wood casing	1.84	1.46	3.[illegible]
Ordinary steel tubing with plain sockets	1.74	1.46	3.[illegible]
Ordinary wood casing	1.64	1.46	3.[illegible]
Insulators	1.58	1.29	2.[illegible]
Lead-covered wires (clipped direct)	1.40	1.10	2.[illegible]
Insulators (cleat type)	1.34	.96	2.[illegible]

163. The **cost of energy** to be used in a given installatio depends upon the consumption of the lamps and the hour they are burned. It the total watt consumption of an instal lation is multiplied by the average number of hours th entire system is used per year, the total kilowatt-hours wi be the result.

164. A careful study of the practice in many cities an towns shows that the average **number of hours each lamp burned** per year is 280 in residences and 636 in stores; lamp in out-of-the-way places, such as attics, cellars, etc., are no included. These average figures cannot be used for any thing but the roughest kinds of estimates.

165. A kilowatt-hour of electric energy will keep a ligh for one hour:

40	6-c.p. ordinary incandescent lamps
20	16-c.p. ordinary incandescent lamps
30	25-c.p. tantalum incandescent lamps
45	30-c.p. osmium incandescent lamps
30	50-c.p. osmium incandescent lamps
22	feet of linolite

12	50-c.p.	single-glower Nernst lamps
6	100-c.p.	two-glower Nernst lamps
4	150-c.p.	three-glower Nernst lamps
3	200-c.p.	four-glower Nernst lamps
4	160-c.p.	miniature colored arc lamps
2	1000-c.p.	ordinary open type arc lamps
2	730-c.p.	enclosed arc lamps
2	1700-c.p.	8-amp. golden or silver flame arc lamps
1.75	2400-c.p.	10-amp. golden or silver flame arc lamps
1.39	2500-c.p.	12-amp. golden or silver flame arc lamps

SECTION 4

HEATING ENGINEERING

SECTION 4

HEATING ENGINEERING

PRINCIPLES

1. All forms of **energy** can be completely **transformed into heat** energy, but when the process is reversed and it is attempted to transform heat energy into any other kind, considerable losses always occur. Electric energy is a secondary form of energy; that is, it does not occur in nature, but must be produced from some primary source, such as coal or water under pressure; and, therefore, the cost of heat from electric energy must always be greater than that obtained directly from a primary source, and without loss.

2. At first it might seem that, because of these **fundamental disadvantages**, electric energy would be too costly a means of producing heat for commercial purposes. However, it is one thing to produce the heat, and another thing to utilize it. Although a given amount of energy in coal can be transformed into an exactly equivalent amount of heat energy, only a part of this heat energy can be utilized, the rest being dissipated without serving any useful purpose. For instance, in steam boilers from 25 to 50 per cent of the heat is carried up the chimney or lost by radiation when under normal running conditions; and when the fires are banked waiting for peak load to come on, practically all the heat is a loss. It is in the utilization of the heat that electric energy is superior to all other forms. With electric energy, heat can be produced instantaneously in any desired amount and applied just where it is needed, almost without loss of any kind.

3. It is misleading and unfair to compare electric heat with heat from other sources, unless the **efficiency of utilization** is properly *taken into account*. When operating conditions are *assumed just as they* actually are, electric energy will

often turn out to be more economical than other fo heating. For example, take an electric flatiron: it nomical of the heat, and, therefore, does not heat the ro tire the operator; it is always at the right temperatı need not be exchanged for a new one, thus saving the work itself and entirely eliminating the trotting from the stove; therefore when the cost of ironing a amount of clothes is taken as a measure of the ec instead of the price of the energy, it may well be that heat will be found to be the cheapest.

4. Electric heat is produced by passing electricity t a **resistor**, and the rate at which heat is produced is proportional to the product of the resistance in ohms resistor and the square of the current in amperes. only **moderate temperatures** are to be attained, the element usually consists of a resistor alloy in the foı long thin wire, a flat ribbon, or a thin sheet througk electricity is made to pass. The rate at which the produced is a fundamental relation and can be acc determined from the resistance and the current, as de above, entirely independent of what the design may l the temperature depends on the radiation and condu heat away from the heated body. If the thermal re of the substance between the heating element and the to which the heat must be transmitted is high, the te ture of the heating element will have to be raised ve siderably above that at the surface, in order to trans heat at the same rate it is generated; so that, when ap is not properly designed, the temperature of the element itself may be unnecessarily high.

5. For **high temperatures**, large cross-section r are used so as to stand the heat; as the resistance low voltages are used. In welding, the greatest developed right at the joint because at this point t more resistance than at any other point in the circı as the resistance is low a relatively low voltage ha used (5 to 10 volts) according to the size of met therefore the amperage is large.

6. The **highest temperature** is obtained with the *arc. This kind* of heating is used in certain types of *furnaces, for* cutting structural steel, etc.

ELECTRIC HEATING IN THE HOUSEHOLD

7. The **apparatus** employed **for heating or cooking** consists of some form of resistor, such as long coils of wire covered by a suitable protective coating. The heating elements are designed to give a uniform temperature, and to conduct the heat rapidly and evenly to the device to be heated. Uniformity of operation is very essential if the apparatus is to be durable and remain reliable at the high temperatures at which most electrical heating apparatus is operated.

8. Air jacketing or other **non-conducting protection** is employed wherever possible, so that radiation from cooking vessels may be reduced and convection losses be as small as possible. The exterior of the vessels is polished or plated for the same reason. As the utensils are not subjected to any deleterious fumes or to smoke, they do not readily tarnish.

9. In **properly designed apparatus** the heating element forms a part of the device to be heated, or must be closely in contact with the part of the apparatus to which the heat is transmitted. The heated surface or the heating element should be constructed to be easily removed for repair or replacing, for though they last a long time, the chances are that their life will not be as long as that of the apparatus of which they form a part.

10. In **wiring** for electric heating and cooking appliances no other precautions are necessary than those adopted in ordinary electric lighting installations. Where the heating apparatus consumes 500 watts or over, the ordinary lamp sockets should not be used, but special wall plug receptacles employed in their stead, each controlled by a separate switch in the same room.

11. Under no circumstances should heating or cooking apparatus be used on circuits of **voltages** more than 5 per cent higher than that marked on the name plate attached to each article, when articles are marked for one voltage; but when a range is given, for example 100 to 125 volts, this must not be exceeded or the apparatus will be spoiled. On the other hand, if the apparatus is put on circuits of lower voltages than it is designed for, it will not heat quickly enough

12. The heating apparatus should never be **immersed in water** unless intended for that purpose, and cooking apparatus must not be allowed to **boil dry** or it will be spoiled, just as it would over an ordinary fire.

13. In the event of any electrical **heating device failing** to do its work, it is the wisest plan to look and see if the plug and cord are in good shape and then write to the manufacturer, giving voltage, catalogue number, and serial, and ask for a new part, or where to ship the apparatus. Never take it apart until the manufacturer states it is all right to do so.

14. When **the flexible cord** used to connect the wall plug receptacles with the heating apparatus becomes frayed, worn or kinked, it should immediately be repaired, as otherwise when the wear becomes greater through neglect, it is likely to short circuit and the fuses may blow out; and then there is the inconvenience of doing without the apparatus until the fuse is replaced and the cord repaired.

15. In residences it is advisable to provide a separate [illegible] throughout if it is proposed to use radiators and electric [illegible], since this allows of a **separate meter** being employed. The rates for motor and heating apparatus in [illegible] are very much lower than those for lighting. [illegible] articles such as flatirons, curling-iron heaters, [illegible] pads, hot plates, teakettles, chafing dishes, etc., [illegible] so little energy in the course of a month that [illegible] operating them at lighting rates is inappreciable, [illegible] is not worth while to put in a separate circuit [illegible]

16. [illegible] **range** [illegible] of three or four disk stoves, 5- to 8- [illegible] by 12 inches, mounted on a cast- [illegible] to the top of oven 12 by 18 by [illegible] three-heat switches mounted [illegible] cooking utensils. [illegible] purchased at retail for [illegible] $ [illegible] four to six. $ [illegible] larger sizes for larger places. [illegible] gas range [illegible]

17. [illegible] **water heater** [illegible]

same principle as the small gas heaters. Retail price, $30.

18. Both these **devices** should be **controlled** by a knife switch right in the kitchen, with a small pilot lamp so as to show when the current is turned "on," and then the possibility of wasting energy is reduced.

21. Cooking utensils are constructed in two ways: they may be combined with the electric heater, or they may be separate from the heater. In the former case there is a slight saving of energy effected, but against this has to be placed the increased cost of the combined articles and the greater difficulty of cleaning them, as they are heavy and cannot be immersed in water, also the impossibility of using the heater in connection with any other appliance. There is an advantage, therefore, in having the utensil and the heater separate.

22. When separate utensils are employed, care must be taken to choose only those that have flat bottoms, or better still those that clamp to the stoves, as they operate about 30 to 40 per cent quicker; for if they do not come well into contact with the hot plate, a loss of energy will result due to radiation. Wherever heat encounters high resistance, such as in an air space or any other non-conductor, the temperature of the radiating surface must rise until it reaches a point where the heat can be carried off as fast as it is produced, and an unnecessary use in temperature means increased radiation losses. A sooty saucepan or kettle taken off a coal fire should never be used on an electric stove, as the dirt prevents rapid and economical heating.

23. Electric Heating. — The electric **radiator** has a wide field of usefulness, although it is not commercially practical to heat residences or large buildings, except in rare cases of very low cost of energy. While for continuous service the operating cost is too high under most conditions, for occasional demand they are economical and supply heat in an ideal manner. When in operation all the electric energy supplied is converted into heat, whether operating at full capacity or less. The control is simple and the supply can be varied to meet the demands. There being no combustion, there is no vitiation of the air and, of course, no noise, *dirt, odor, unsanitary* or objectionable features.

24. No definite rule can be given to determine the amount of electric energy for **heating a given space** without knowledge of all conditions to be met, but approximate estimates can be made by allowing two watts per cubic foot of space for well-constructed buildings in cold weather; one watt for warm climates and three for extremely cold climates.

25. The electric **radiator in the bathroom** is a luxury and its cost for operating is not expensive. While considerable power is required, usually 2000 watts, the time of service (from 15 to 20 minutes) is short. The cost need never exceed ten or fifteen cents for warming the room for the morning bath.

26. There are two types of electric heaters, luminous and non-luminous. The **luminous radiator** consists of three or four large cylindrical incandescent heating lamps with a reflector behind them, fitted into an ornamental frame. These lamps differ from ordinary incandescents, being specially designed to transform electrical energy into radiant heat. The source of heat is a small filament which is heated to incandescence by the electric current. The cheerfulness of a luminous radiator when in use is decidedly attractive, and by employing this method of heating the benefits of an open fire with none of its drawbacks or inconveniences are immediately available through the turning of a switch. If preferred, the radiator may be installed permanently in the fireplace, though in such case the chimney should be hermetically sealed up by cement or other effective means. The chief advantage of this radiator is its portability.

27. The **non-luminous radiator** is made with enamel plates, open coil resistance wire, cast-iron grids, and cartridge units. The air inside of the heater becomes warm, rises, and is immediately replaced by cold air.

28. It is of the utmost importance that electric radiators of the convector type be placed in **correct positions**, and such positions are to be found where the air is incoming, never where it is outgoing. Heated air always moves with a current and will, if the currents are strong enough, stream out with them, without properly heating the other parts of the room. If the convector is properly installed, there should be an end of cold drafts. Where large rooms are to be heated, several radiators should be employed, because one

heavy current radiator will not give as good results as a number of smaller ones taking the same energy collectively, since the latter will distribute the heat more uniformly over the room.

34. Domestic Heating Devices. Watts consumed and Cost of Operation based on 5 ct. per Kw-hr.

Apparatus	Watts	Cents per Hour
Broilers, 3 ht.	300 to 1200	1.5 to 6
Chafing dishes, 3 ht.	200 to 500	1 to 2.5
Cigar lighters	75	0.375
Coffee percolators for 6-in. stove . .	100 to 440	0.5 to 2.2
Coil heaters	110 to 440	0.5 to 2.2
Corn poppers	300	1.5
Curling-iron heaters	60	0.3
Double boilers for 6-in., 3 ht. stove .	100 to 440	0.5 to 2.2
Flatiron (domestic size), 3 lb. . . .	275	1
Flatiron (domestic size), 4 lb. . . .	350	1.4
Flatiron (domestic size), 5 lb. . . .	400	2
Flatiron (domestic size), 6 lb. . . .	475	2.4
Flatiron (domestic size), 7.5 lb. . .	540	2.7
Flatiron (domestic size), 9 lb. . . .	610	3.05
Foot warmers	50 to 400	0.25 to 2
Frying kettles, 8 in. diameter . . .	825	4.125
Griddle-cake cookers, 9 in. by 12 in. 3 ht.	330 to 880	1.7 to 4.4
Griddle-cake cookers, 12 in. by 18 in., 3 ht.	500 to 1500	2.5 to 7.5
Heating pads	50	0.25
Instantaneous flow water heaters . .	2000	10
Kitchenettes (complete), average . .	1500	7.5
Nursery milk warmers	450	2.25
Ornamental stoves	250 to 500	1.25 to 2.5
Ovens	1200 to 1500	6 to 7.5
Plate warmers	300	1.5
Radiators	700 to 6000	3.5 to 30
Ranges: Three heats, four to six people	1000 to 4515	5 to 22
Ranges: Three heats, six to twelve people	1100 to 5250	5.5 to 26
Ranges: Three heats, twelve to twenty people	2000 to 7200	10 to 36
Shaving mugs	150 to	.75
Stoves (plain), 4.5 in., 3 ht.	50 to 220	0.25 to 1.1
Stoves (plain), 6 in., 3 ht.	100 to 440	0.5 to 2.2

DOMESTIC HEATING DEVICES (Continued)

APPLIANCE	WATTS	CENTS PER HOUR
[illegible]	[illegible]	[illegible] 3
[illegible]	[illegible]	[illegible] 4.125
[illegible]	[illegible]	[illegible] 5.5
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible] 4.4
[illegible]	[illegible]	[illegible] 7.5
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

[illegible] watt-hours per [illegible] cooking; [illegible] kilowatt-hours per day is an [illegible]

[illegible]

[illegible]	[illegible]	[illegible]	Oven [illegible]	Broiler Beefsteak [illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

37. Electric Heating Devices for Commercial Purposes. Watts Consumed and the Cost of Operation based on 5 ct. per Kw-hr.

Apparatus	Watts	Cents per Hour
Annealing furnaces	200	1
Bar or barber's urns, 1 to 5 gals., 3 ht. .	200 to 1700	1 to 8.5
Baker's ovens, 30 to 80 loaves . . .	6000 to 10,000	30 to 50
Cigar lighting	75	0.375
Corset irons	350	1.75
Dental furnaces	450	2.25
Glue pots	110 to 880	0.5 to 4.4
Hat irons (small)	200	1
Hatter's iron, 9 to 15 lb.	450	2.25
Instrument sterilizers	350 to 500	1.75 to 2.5
Laboratory apparatus flask heaters . .	500	2.5
Machine irons, 12 to 18 lb.	770	3.375
Pitch kettles, 12 and 15 in., 3 ht. . .	300 to 1500	1.5 to 7.5
Polishing irons, 3.5 to 5.5 lb.	330 to 450	1.7 to 2.5
Radiators (various sizes)	700 to 6000	3.5 to 30
Sealing-wax pots, .5 and 1.5 pt. . . .	175 to 300	0.75 to 1.5
Shoe irons	200	1
Soldering irons (various sizes) . . .	100 to 450	0.05 to 2.25
Soldering pots, 4 to 10 lb. capacity . .	200 to 440	1 to 2.2
Tailor's iron, 12 to 25 lb.	660 to 880	3.3 to 4.4
Vulcanizers for automobile tires . .	100 to 450	1 to 2.25

38. Standard Sizes of Electric Baking Ovens

Outside Dimensions in Inches			Number of Shelves	Sq. Ft. Baking Surface	Number Loaves One Baking	Kw. Full Heat
Wide	Deep	High				
32	28	50	3	12	30	6
37	29	58	4	18	48	8
37	29	66	5	24	60	9
42	29	66	5	28	80	10

Other special sizes built to order.

Note. — *These are cabinet* ovens, built of galvanized iron, having shelves about ...rt *and an independent* drop door for each shelf.

[illegible] bake evenly on all the shelves, and while adapted [illegible] to bread, cake, and pastry, can be used for roasting with perfect success. With the large size, for example, [illegible] by 66 in., 960 loaves of bread can be turned out in [illegible] than eight hours, starting with the oven cold, at an [illegible] of less than 80 kw-hr. or at the rate of about [illegible] five cent loaves per kw-hr.

39. Bookbinders' Apparatus

[illegible] heated head.	Load factor[1]		12 to 20 per cent
[illegible]	110 volts		235 watts
[illegible]	110 volts		375 watts
[illegible] (full head)	110 volts		3300 watts

[illegible] bench lever stamper

[illegible] amp.	110 volts		1650 watts
[illegible] heaters	Load factor 50 per cent		
[illegible]	110 volts	6 amp.	500 to 660 watts
[illegible] press head	2 amp. to 20 amp., according to size		
[illegible]	110 volts	Load factor 40 per cent	
[illegible] watts, running 148 watts, cost 0.75 ct. per hour			
[illegible] watts, running 203 watts, cost 1 ct. per hour			
[illegible] heater 110 volt	100 amp. max.	40 amp. min.	

40. Candy Manufacturing and Confectioners

[illegible] dipping pan
[illegible] chocolate . 110 volts, start 150 watts, running 50 watts, cost about 0.25 cent per hour

[illegible] . 110 volts . 12 amp. start, running 4.5 amp.

[illegible] . 110 volts . 12 amp. start, running 2.5 amp.

[illegible] funnels 110 volts . 30 to 100 watts

41. Cigar Lighters

[illegible]	2 to 10 per cent
[illegible] generates an arc between [illegible] rodes	220 watts
[illegible] heats a coil to white heat	75 watts

[1] Load factor is her[illegible]

42. Electrotyping

ax stripping table 26 in. by 34 in.	225 volts	27.1 amp.
ax kettles		Load factor 33 per cent
20 in. diameter, 17 in. deep	225 volts	16.5 amp.
omposition kettle		Load factor 40 per cent
18 in. diameter, 13 in. deep	225 volts	18 amp.

43. Forge. — Electric forge consists of metallic vessel ntaining an acidulated aqueous saline solution. The ositive pole is the vessel itself, while the metal to be heated attached to the negative pole and dipped into the solution. ne hundred and ten volts is impressed on the circuit, and e heat is rapidly developed at the point of contact.

45. Hat Factory

urling machine, Seg-schneider type . . .	110 volts	1 amp.	
urling block for tweedy machine	110 volts	6.5 amp.	
urling block for Turner edging machine . .	110 volts	6.5 amp.	
eating attachment for Agar curler . . .	110 volts	2.5 amp.	
langing bag heater .	110 volts	8 amp. start.	Average 440 watts
land flat for straw hats	110 volts	6.5 amp. start.	Average 550 watts
roning block for Reid machine	110 volts	4.5 amp.	
roning block for Yale machine	110 volts	4.5 amp.	
hackle stoves, hooded type	110 volts	5 amp.	
elouring stoves . . .	110 volts	4 amp.	
orming irons	110 volts	3 to 8 amp.	
land shell	110 volts	2.5 to 3.5 amp.	

46. Kilns. — The burning of china in electric kilns reaches he highest measure of perfection on account of the fine eat regulation.

Japanning ovens use about 40 watts per cubic foot of air pace, depending entirely upon the mass of metal to be ired.

47. Laundry

Bosom ironer	Load factor 59 to 79 per cent
Roll, 10.5 in. long, 8 in. diameter	110 volts max. 16.8 amp. Average 1450 watts. Usually in sets of three
Neck band ironer 6 in.	3.5 amp. 110 volts. Average 350 watts
Sleeve machine	12.4 amp. 110 volts. Average 1234 watts
Body ironer 36 in.	41.5 amp. 110 volts. Average 4563 watts
Yoke machine	6 amp. 110 volts. Average 575 watts
Collar and cuff ironer	Load factor 50 per cent. 6.5 amp. 110 volts. Average 600 watts.
Rotary collar tipping machine . .	3 amp. 110 volts. Average 250 watts
Heim collar shaper	Load factor 40 per cent. 5.5 amp. 20 volts. Average 100 watts
Hand collar edging machine . .	6.25 amp. 20 volts. Average 115 watts
Pressing irons, 110 volts.	5-lb. 400 watts. 7-lb. 450 watts. Load factor 40 per cent

48. Paper Mills. — Drying rolls of endless cloths usually used on three rolls. For a capacity to evaporate 120 lb. water the rolls would use —

	671 watts
	895 watts
	1044 watts
Total	2610 watts

49. Paper Box Makers

Glue cooker, 25 gallons' capacity	110 volts 1000 watts. Average run 800 watts.
Inman box-covering machine . .	Load factor 79 per cent. 5 ft. by 9 ft. carries 1 qt. glue, 110 volts 1.5 amp. 165 watts.
Knowlton and Beach belt machine 1-pint pan and 5-gallon glue reservoir	Load factor 77 per cent. 110 volts 1 amp. on pan, 5 amp. on reservoir. Average 610 watts
Glue pots, 2-qt.	1.3 amp. to 1 amp.

50. Printing

Monotype machine	1, max. 2200 watts, min. 900 watts. Average 1400 watts
Matrix drying table, average working temperature 325 deg. F., 25 in. by 32 in.	110 volts 2432 watts. Load factor 50 per cent
Press blanks for color work . .	Load factor 25 per cent. 110 volts 9 amp. 1000 watts
Sweating plate, 14 in. by 14 in. . .	110 volts 7.4 amp. to 14.8 amp. Average 1200 watts
18 in. by 25 in.	110 volts 19 amp. to 38 amp. Average 3200 watts
Felt burners for taking down the bolsters which form on the blankets of large cylinder presses. .	110 volts 100 watts.

51. Sawing. — Hot wire cutting used in veneering, immense saving over band sawing. The mechanical saw is thicker and wastes its thickness every cut. Consumption of current varies with length of wire.

52. Shoe Factory

Shoe stamping machine. Circular die head	110 volts 4.5 amp. 500 watts. Load factor 80 per cent.
Shoe ironing tools	200 watts. Load factor 60 per cent.
Treeing machines.	—watts.

53. Soldering Irons

On steady work	Load factor 50 per cent.
On intermittent work	Load factor 10 per cent. 110 volts 4 amp. Average 220 watts.
Small irons for telephone work .	any voltage up to 125 90 watts.
4.25 lb. iron for heavy work . .	any voltage up to 250 425 watts.

In general allow 100 watts for each pound weight of *soldering iron.* Weights 8 oz. to 70 oz. Soldering irons

must not be used with free acid. Use a paste or rosin, as acid eats up the iron in a very short time, and the fumes eat the resistance wire.

A factory using 25 irons paid in 1905 for gas $502. After substituting electric irons $422 was paid for electric energy for equivalent period, and there was also a gain in output of product.

54. Upholstery Goods

Finishing ironing machines. Cylinder 20 in. diameter 5 ft. long. Average 17 kw.

55. Water Heaters

Circulating, 30 gallons' capacity . 110 volts 3000 watts.
Average consumption 850 watts gives temperature 116 deg. F.

Circulating, 60 gallons' capacity . 110 volts 6000 watts.
Cup-shaped, 1-pint capacity, 300 watts. Boil water in 5 minutes, starting at faucet temperature.
Cup-shaped, 1-quart capacity, 500 watts.

Immersion coil heaters.
For heating liquids in any vessel, made in flat coils and cylindrical coils, one and three heats. All sizes from 3.5 diameter up to 12 in. or more . . . . 110 volts.

Coils consuming	will boil 1 quart of water in
400 watts	19 minutes
900 watts	17 minutes
2000 watts	3 minutes

Instantaneous water heaters.
Attached on water supply pipe . 4000 watts.
Will heat a glass of water to 160 deg. F. in 40 seconds.
Will heat 1 quart of water to 105 deg. in 40 seconds.
Will heat 1 gallon of water to 170 deg. F. in 10 minutes.

56. Welding. — Alternating current, usually with transformer reducing to 5 to 10 volts. On very small work 10 volts can be used. Special welding machine is required.

Cross-section Square Inches	Diameter of Round Bar in Inches.	Watts	Material
0.05	0.25	1,500	iron or steel
0.25		6,700	iron or steel
0.30	0.625	9,000	iron or steel
0.6		13,500	iron or steel
0.02		3,750	copper
0.11	0.33	12,750	copper
1		60,000	copper
0.75	1	46,000	copper
1		21,000	iron or steel
0.79	1.25	16,500	heavy iron pipe
3	3	62,000	heavy iron pipe

57. The time necessary to accomplish a weld is very short, ying from two seconds in the small pieces up to thirty onds, except in the very large welds; for instance, three are inches of cross-section might take two minutes. So t even for heavy work the actual current consumption ot excessive.

58. **Example.** — Wagon tires 1 in. wide, 0.25 thick, 6.75 . for 25 seconds would cost less than 0.25 cent per weld. welds could be accomplished in an hour.

59. **Wrecking and Construction.** — The electric arc can used very advantageously for **cutting off** the projecting ds of **steel piling**, when building the foundation for heavy ildings, or when wrecking steel work. A plant operated in w York City on alternating currents employed four 20-kw. gle-phase transformers connected in multiple, the second- e. m. f. being 50 volts. One side of the circuit was con- cted by a wire bolted to the steel, and the other was nnected directly to a carbon electrode. The carbon elec- de was 1.25 in. in diameter, and 10.75 in. long, and was mped between two copper plates 5 in. square by 0.5 in. ck. The operator must wear an asbestos mask and gloves protect himself from heat, the mask being fitted with uble black glass goggles to protect the eyes from the strong ht. This plant required 650 amp. at 50 volts, and in an ht-hour day 10 ft. of steel piling were cut, the cut vary- in depth from 0.5 in. at the center of a pile to 3.5 in.

at the ends, with an energy consumption of 256 kw.-hr. With energy at 10 cents per kw.-hr., this device saved over $10 a day in labor, to say nothing of the value of the time gained.

ELECTRIC HEATING CALCULATIONS

60. If it is desired to estimate the proportion of the lighting bill which is due to energy used for heating purposes, the following is a simple method of ascertaining it approximately: find out first the **lamp equivalent** for the heating device in question. The usual 110-volt, 16-c.p. carbon-filament electric lamp requires 56 watts. Therefore, divide by 56 the number of watts consumed by the heater (this figure will be obtained from name plate or the maker's catalogue); the result will be the lamp equivalent for the heater. Then knowing the cost of operating a lamp for one hour, it is easy to calculate the cost per hour for the heater.

61. If heating apparatus is employed to any extent, it will pay the user to instal a **separate heating circuit** connected to another meter, as the price for electric current for heating is generally lower than for lighting.

62. In the maker's catalogue, and stamped on each piece of apparatus, will be found the watts taken by the particular apparatus after attaining its normal temperature when connected in the position of maximum heat.

63. The number of watts divided by 1000 and multiplied by the fraction of an hour the apparatus is connected to the supply mains, will give the **kilowatt-hour consumption**, which is the unit registered on the meter and upon which the charge made by the electric supply company is made. As an example of the calculation referred to, consider a piece of apparatus rated as 500 watts and connected to the circuit for twelve minutes. Twelve minutes is $\frac{12}{60}$ or $\frac{1}{5}$ or 0.2 of an hour, so the total kilowatt-hour consumption is $\frac{500 \times 0.2}{1000} = 0.1$, or one tenth of a kilowatt-hour. The consumption is sometimes given in amperes (the unit of flow of electricity), in which case the number of amperes multiplied by the voltage of the circuit will give the total watts. The total kilowatt-hour consumption can then be calculated as in the instance given above.

64. If the watts are given and it is desired to ascertain **ow many amperes** are required, the watts should be divided y the voltage of the circuit.

66. In kettles, stewpans, etc., and most of the utensils esigned for heating liquids, the time required is about 10 to 4 minutes to boil. With plate warmers, foot warmers, hot upboard, etc., and most of the apparatus in which slow-eating apparatus is employed, the time is from 10 to 20 ninutes. In hot plates, grills, and other high-temperature pparatus, the time required is from 2 to 6 minutes.

67. Time taken **to heat water** in any quantity to any defi-ite temperature not exceeding boiling point can be deter-nined from the formula: —

$$t = \frac{V(T_2 - T_1)1834}{P \times \eta}$$

Where t equals time in minutes.
Where V equals number of pints (U.S.).
Where T_1 equals initial temperature in degrees F.
Where T_2 equals final temperature in degrees F.
Where P equals consumption in watts.
Where η equals electrical efficiency per cent.

68. As an example take the instance of the teakettle whose electrical efficiency is 90 per cent, consumption 450 watts, and contains 1.5 pints of water at 62 deg. F. The final emperature is that of boiling water, namely, 212 deg. F. Substituting the known value in the formula, the following s obtained: —

$$t = \frac{1.5 \times (212 - 62) \times 1834}{450 \times 90} = 10.20 \text{ minutes.}$$

69. The *cost of heating* any quantity of *water* can be determined from the formula: —

$$C = \frac{c \times V(T_2 - T_1)\,0.0306}{\eta}$$

Where C equals cost in cents.
Where c equals rate charged in cents per kilowatt-hour.
Where T_2 equals final temperature in degrees F.
Where T_2 *equals initial* temperature in degrees F.
Where η equals electrical efficiency per cent.

Taking the price of electrical energy at 3 cents per kilowatt-hour and the electrical efficiency at 92.5 per cent [illegible] age for kettles, jugs, etc.), then the cost of raising one [illegible] water from 42 deg. F. to 212 deg. F. will be:—

$$c = \frac{3 \times 1(212 - 42) \times 0.0306}{92.5} = 0.17 \text{ cent.}$$

70. From the formula already given it will be noted that the product of watts and the time required to raise a given quantity of water to any particular temperature is a constant. Therefore if it is desired to shorten the time of heating the water to the required temperature, the watts must be proportionately increased. Table 71 gives the cost of heating water to various temperatures at several different rates per kilowatt hour, when the required temperature has to be attained in 5, 10, 20, and 60 minutes respectively. From this table it will be noted that though the cost is independent of the time, the carrying capacity of the wires must be very much greater when the heating has to be done in a short time.

71. Watts Required to Boil Water and Cost of Operation at Various Rates per Kilowatt-hour. Initial Temperature of Water 60° F. Efficiency of Apparatus [illegible]

1 Pint of Water

[illegible]	Watts Used for Minutes				Cost in Cents with Electricity at Given Rate per Kw-hr.			
	5 min.	10 min.	20 min.	60 min.	3¢	5¢	10¢	20¢
[illegible]	173	87	43	14.4	.04	.07	.14	.29
[illegible]	[illegible]	105	97	32.5	.10	.16	.32	.65
[illegible]	[illegible]	240	124	41.5	.12	.21	.41	.83
	[illegible]	303	152	50.5	.15	.25	.51	1.01
[illegible]	[illegible]	320	165	55	.17	.27	.55	1.10

1 Quart of Water

[illegible]	[illegible]	173	87	20	.09	.14	.29	.58
[illegible]	[illegible]	390	105	65	.19	.32	.65	1.30
[illegible]	[illegible]	498	240	83	.25	.41	.83	1.66
[illegible]	[illegible]	606	303		.30	.51	1.01	2.02
[illegible]	[illegible]	658	32[illegible]		[illegible]3	.55	1.10	2.20

1

1 Gallon of Water

100°	1385	693	346	115.5	.35	.58	1.155	2.31
150°	3117	1559	779	260	.78	1.3	2.6	5.2
175°	3983	1992	996	332	1	1.66	3.32	6.64
200°	4849	2425	1212	404	1.21	2.02	4.04	8.08
212°	5265	2632	1316	438.7	1.32	2.19	4.39	8.77

Formula: $P = \frac{V(T_2 = T_1)\ 18.4}{tn}$ in watts.

V = pints.
T_2 = final temperature deg. F.
T_1 = initial temperature deg. F.
t = time in minutes.
n = efficiency.
18.4 = watt = min. = 1 pt.-deg. F.

72. The **heat required to raise the temperature of a given space or room** to a certain value depends upon the ventilation, the character of the walls, the dimensions, proportions of the room, etc. If the walls were perfect non-conductors, it would require a certain amount of money to raise the temperature to a given value, but none to maintain it. However, since heat will be carried away from the space by conduction through the walls and by renewal of the air through ventilation, energy must be supplied at such a rate as to just take care of these losses. Therefore, it is seen that together with ventilation the conductivity and area of the walls determine the power or energy rate necessary to maintain the given temperature difference between the air inside of the space and the outside surface of the walls.

73. Figures are often given based on so many watts per cubic foot of space, but such figures are fundamentally wrong, as can readily be seen by comparing the heat necessary to warm a long, narrow room with that necessary to heat a square room of the same volume, the character of the walls being the same in both cases.

74. It requires one watt-hour of **electric energy to raise the temperature** of one cubic foot of air about 200 deg. F. In addition to raising the temperature of the air to the desired value, the loss of heat through conduction and ventilation must be supplied. In a properly constructed house *the loss through* conduction is negligible when compared to

the energy necessary to raise the temperature of the cold air coming in for ventilating purposes. Electric energy supplied at the rate of one watt will raise the temperature of a cubic foot of air at the rate of 0.0556 deg. F. per second, or approximately 3.3 deg. per minute. The power required to keep the temperature at a given value can be roughly estimated by assuming the number of cubic feet of air which are required per minute for ventilation, and multiplying this by the number of degrees which the temperature must be raised, then dividing the product by 3.3 we obtain the number of watts necessary to maintain the temperature. For example, assume a room 15 by 15 ft. and 10 ft. high, in which the air is changed three times an hour, the temperature to be maintained 30 deg. above the outside. The volume of the room $= 15 = 15 \times 10 = 2250$ cu. ft.

$$\frac{2250}{20} = 112.5 \text{ cu. ft. per min.}$$

$$112.5 \times \frac{30}{3.3} = 1020 \text{ watts necessary to supply ventilation loss.}$$

To begin with, the air in the room must be raised 30 deg. This will require

$$2250 \times \frac{30}{200} = 370 \text{ watt-hours.}$$

Therefore, the total energy used during the first hour will be $1.020 + 0.370 = 1.390$ kilowatt-hours, and during the succeeding hours it will be 1.020 kilowatt-hours per hour. It will be noticed that by far the largest part of the energy is used by supplying the loss due to ventilation.

HEATING APPLIANCE DEPARTMENT

90. Heating apparatus makes a very desirable load for central stations, and one that can be steadily increased by conducting what amounts to an educational campaign on electric heating. The subject is comparatively new, and the appliances are rather dear, so that a customer is not liable to purchase just to satisfy his curiosity, but must be convinced of the economy and convenience of the system *before he is willing* to put his money into it.

91. The best way of getting and holding the public's interest is by actual demonstration, both in a public place set apart for the purpose, and in the homes of the prospective customers. In order to carry on such a campaign, a special department should be organized for taking care of the sale and demonstration of appliances. The appliance department should not be limited to heating devices, but should handle all sorts of electrical devices in which the public at large is liable to be interested.

92. Appliance Department System.— Accurate record should always be kept of the work of the department so that it may be known at all times where the department stands as an investment.

93. Of first importance is the **list of prospective customers.** This list should include all residence customers. It will be found that people of moderate means are the best prospects for flatirons.

94. Where a woman is employed to canvass residences, **daily reports** should be exacted showing on whom she has called and with what results. A simple system will suffice for this, the object being: (1) to record all calls and note status of prospect; if a second call is advisable, to provide for a reminder of it at the proper time; (2) to account for all goods left on trial, if any; to account for goods taken back from trial with reason why they were not kept; (3) to account for all collections made, if any. This report may be made on a single sheet each day and filed until the end of the month, when a monthly business statement of the business may be made.

95. An **office record** should be kept for the department, showing: (1) goods taken from stock and kept on display; (2) goods sold and paid for, with wattage, for purpose of estimating probable consumption; (3) goods sold and charged; (4) goods out on trial; and (5) goods returned.

96. This record can best be kept on a card system which admits of frequent going over for the purpose of keeping in touch with the work of the department.

97. A complete catalogue including all their goods should be made up from the lists of all makers of electric heating appliances, which should contain details of prices and all other pertinent information, and be cross-indexed to show

the different industries in which the appliances are used. Such a catalogue will be found invaluable as a guide to possible users of industrial heating apparatus.

98. The **arrangement of a stock** of heating and other appliances should be such as to minimize care, handling, and record-keeping, and also eliminate errors in placing orders for replenishment of stock.

99. Stock shelves should be in a dry, temperate room. The shelving should be shallow so that the entire stock is in plain sight, and to prevent accumulations of miscellaneous rubbish behind the stacks of appliances, as is sure to be the case where shelving is deep and more or less inaccessible. Stock shelves should be plainly labeled and numbered.

100. Heating appliances should be kept carefully wrapped and boxed. Articles for which the call is slight, and which may be in stock for some time, should be extra wrapped and sealed with sealing wax to prevent deterioration. Each package should be carefully marked so that it need not be opened until wanted for display or sale.

101. A **stock record** system should be rigidly kept, such system depending as to detail upon the amount of stock kept and other local conditions. The objects sought by such a system are: (1) record of orders placed for goods; (2) record of goods received and particulars as to their condition on receipt; (3) record of goods taken from stock for display; (4) record of goods taken from stock for sale; (5) record of goods put out on trial.

102. The object of a **heating appliance display** is to interest prospective customers in the devices and to educate them in their use. And it is obvious that a small but well-arranged display is better than a large, meaningless jumble.

103. When **arranging displays** have as few articles as possible and surround them with natural accessories. Thus, a single flatiron connected to a circuit and placed upon an ironing table with its stand, a garment for ironing, a dish of water for the sprinkling, etc., will be far more effective than a number of irons alone, and not connected. A good-sized card, neatly lettered, explaining in few and simple words the advantages, price, and cost of operation, completes this display.

104. *In similar* fashion displays of coffee percolators,

afing dishes, teakettles, and other tea-table appliances ould be placed upon a regular tea-table spread with clean en or doilies, and surrounded with the natural accessories, ch as dishes, a bowl of fresh flowers, a portable lamp, etc.

105. All articles on display should be connected to circuit d ready for instant demonstration. Any defective applices should be removed for repair. Prices should be marked plain figures, so that any employee, whether familiar th the goods or not, could make a sale, and it should be e duty of all employees in the office to be sufficiently familiar th the goods to speak intelligently as to price, cost of operan, and performance.

106. Electric irons, chafing dishes, coffee percolators, asters, and other **apparatus** may advantageously be put t **on trial**, as they are almost sure to prove so satisfactory at the customer will desire to purchase them if the matter properly followed up.

107. The same **care** should be **given** these **goods** as is ven by a jeweler to his stock. Displays should be dusted ily at least once, and all nickeled appliances should be refully wiped.

108. A **display case** of glass should be provided into which l appliances, such as percolators, chafing dishes, etc., may placed. This case should be kept closed to exclude mpness. It may be so arranged as to be an example show-case lighting by installing fixtures inside with a nvenient switch so that the lamps may be lighted whenever customer is being shown an appliance.

109. Where goods are offered on trial all **appliances** hich are returned should be carefully **inspected**, repaired, d if necessary refinished before being put in stock again. arnished or damaged appliances should never be allowed remain where a customer might see them.

The management of a central station about to engage in e exploitation of such devices should make especial forts to encourage the installation and use of this class of paratus on its lines.

110. The **salesman** should of course be fully posted on e relative merits of various kinds of apparatus, and should ow why the apparatus he offers is the best in points of *rability, efficiency,* and economy. To obtain this informa-

tion the salesman should try to **associate with the salesman** direct **from** the **factory** where these devices are made in order to imbibe their enthusiasm and knowledge, and also their views of their own apparatus and that of others. Gradually the active advantages and disadvantages of the various makes will arrange themselves in his mind, and he will at the same time see why one method of manufacture costs more than another, or less, and why this or that article is best suited for certain work.

111. A salesman should never attempt to **demonstrate** an **appliance** with which he is unfamiliar, not only as to general characteristics, but as to current consumption, time necessary to reach working point, and method of operation. The object of demonstration is to show how easily, swiftly, and economically any electric appliance can perform its functions, and awkwardness or ignorance on the part of the demonstrator immediately reflects discredit upon that appliance.

112. In demonstrating any device it should be remembered that a reasonable **time must be allowed** for it to heat to working point; the switch should not be thrown and then the time of waiting passed in silence. A few minutes may seem an eternity to a customer who is accustomed to see a lamp lighted at the touch of a button, so the interval should be filled with an explanation of the construction of the device, manner of attaching the cord, workings of the separable plug, and other vital items. It should always be stated to the customer that it takes a few minutes for the device to heat up, and no anxiety or impatience should be displayed by the demonstrator.

113. Demonstration of household appliances in the homes of customers is better done by a woman than a man, and the flatiron or curling-iron heater are best for such work, being easily carried and readily shown. The advantage of sending a woman demonstrator instead of a man is that she will be admitted to a customer's house where a man, under many circumstances, would not be allowed to enter, and her efforts to bring other electric appliances than the one she is showing to the attention of customers will not be resented, as they might be with a man. Choice of demonstrator should fall upon a woman of middle age, of pleasing per-

sonality and good manners. She should be taught as much as possible of the company's policy, and it should be part of her duties to handle complaints wherever found.

114. Demonstrating of appliances **to dentists, laundries, tailor shops**, etc., is best fitted for a man to do. These cases are generally straight business propositions, and too much study cannot be given the customer's needs and conditions, with a view to making his adoption of electric heating appliances of distinct financial value.

115. In all classes of demonstration collateral evidence should always be presented to prove the value of the articles demonstrated, such as letters of recommendation, pictures of notable installations, etc.

116. After leaving **articles on trial** the demonstrator should follow up the matter within the next thirty days and learn whether or not they are satisfactory, and if to be returned find out why.

117. Electric heating and cooking devices naturally divide themselves into the two general classes of **domestic and commercial apparatus**. Under the first classification, as the name implies, are placed all utensils used in the home, or for accomplishing all domestic or household operations where heat is necessary. Under the second heading come all utensils used in accomplishing any of the processes employed in commercial or professional enterprises where heat is required.

118. A salesman must recognize at once that **these two classes** demand altogether different **methods of handling**. In one case he is entering, as it were, the domestic circle. In the majority of cases his dealings are with the women of the household. He is, when he gains admittance, introduced into the atmosphere of the home, and should lay aside the manners and methods of the commercial world; a woman, by the way, should be particularly successful in this field, especially if she is familiar with the processes and requirements of general household cooking. The salesman, in order to be successful in exploiting electric heating in the commercial field, requires a much broader knowledge. He should first know of all the various commercial, professional, and scientific processes in which heat is utilized; he should *know the special* requirements in each particular case, the

degree of heat needed, and whether it is possible to apply electric heat, the cost of the old method, its inconveniences and disadvantages, and be able to point out wherein lie the advantages and economies of electric heat; he should be able to tell the prospective customer what wiring is necessary for the introduction of electric heating and its cost, and especially must he be able to give an accurate estimate of the expense of operating in the most efficient and economical manner by means of current.

119. When the **salesman** has **mastered** the **principles of electric heating**, he should make a study of temperature and heat units. It is essential for him to be acquainted with the equivalents of heat and watts, and be able to compute the theoretical amount of heat needed to do a certain kind of work. When attention is drawn to a result that must be obtained, the customer can then be shown just what his bill for current will be for certain work, as compared with bills for gas, steam, or coal. In talking to a customer about heating apparatus do not say that it takes so many watt-hours, but tell him what it will cost in cents per hour to operate the device for the time it takes to perform its work. These features are somewhat on the engineering side of the sales question, and in some cases are not referred to oftener than a few times in a year. When a salesman has to sell to a man who is inquisitive on the subject, and wants facts and figures, he will find that then is the time to use his knowledge, and that the more he knows about the subject the better it will be for him.

120. The use of apparatus with **heat regulation** should always be **recommended**, and customers should be instructed in the use of low and medium heats. Many cooking processes may be accomplished equally well, or better, on low or medium heat as with a higher degree of temperature, with consequent saving of expense.

121. The salesman must remember that although he may be in a pioneer field the sale of his appliances does not differ materially from any other branch of salesmanship. Therefore in approaching a "prospect" he should first **offer** the **device** which he believes will be **most interesting**.

122. Of the many appliances that he will have for sale ***electric flatirons*** are probably the most easily introduced,

and he should be fully informed as to the cost of operating them so as to be able to say, for example, that the average cost of operating a six-pound iron for heavy laundry work will be from $1.00 to $1.25 per month, basing his statement on the use of the iron four days each month with energy at 10 cents per kw.-hr. He should further be able to argue that this will save the time of a laundress — that ironings which would ordinarily consume seven hours can be done in five; that it eliminates heat from the house during the summer and the necessity of keeping up an expensive coal fire. Another feature to be presented to the "prospect" is the economy of storage space where electric cooking and heating devices are used, where much room is saved by the reduction in coal supplies. He should instruct the customer in connecting the iron, and in the principle of the heating element.

123. A certain amount of the solicitor's time should be taken up with interviewing doctors and nurses, interesting them in heating pads and other electric surgical paraphernalia. Here there are many arguments which should show the **advantages of the heating pad** over the old-time hot-water bag, and the superiority of electric surgical appliances over any other.

124. A salesman may very profitably put in a portion of his time **following up sales** already made to satisfied customers, with a view to making other sales, as experience has shown that the desire for electric devices for heating and cooking grows with what it feeds upon.

APPLICATIONS OF ELECTRIC HEATING

Accountants

Sealing-wax heaters

Addressing and Mailing Agencies

Sealing-wax heaters | Glue pot heaters

Amusement Parks

Radiators | Cigar lighters

Apartment Houses

Full line of cooking apparatus
Smoothing irons
Sterilizers
Curling-iron heaters
Radiators
Heating pads
Foot warmers

Assayers and Chemists

Soldering irons
Sterilizers
Water heaters
Annealing furnaces
Enameling furnaces
Vulcanizers

Automobile and Bicycle Shops

Welders
Soldering irons
Branding irons
Enameling furnaces
Armature baking furnaces
Tire vulcanizers

Bakers

Ovens
Waffle irons
Water heaters
Frying kettles
Radiators

Banks

Sealing-wax heaters
Branding irons
Radiators

Barber Shops

Curling-iron-heaters
Hot-water urns
Instantaneous-flow water heaters
Cigar lighters
Radiators

Billiard and Pool Rooms

Glue pots
Cigar lighters
Radiators

Blacksmiths and Wagon Makers

Glue pots
Branding irons
Soldering irons
Welders
Forges

Blue Printers

Flatirons
Electrically heated drying ro

Boat and Ship Builders

pots
ing irons
Welders

Boiler Makers

rs

Bookbinding

pots
ing irons
ing and embossing presses
Matrix drying tables
Lettering and branding irons

Boot and Shoe Manufacturers

pots
and welt machines
g tools
Shoe irons
Branding irons

Breweries and Bottling Works

and resin heaters
ling irons
Radiators for drying casks

Canning Works

ring irons
ling irons
Sealing-wax heaters
Solder pots

Carpenters and Wood Workers

pots
ling irons
Braziers

Churches

tors and foot warmers
Kitchen outfit

Cigar Stores

lighters
Radiators

Cleaning and Dyeing Works

rs' and laundry irons
s
Water heaters

Cloak and Suit Manufacturers

s' and laundry irons

Coffee and Tea Merchants

Coffee roasters
Coffee percolators
Water urns
Stoves

Commission Merchants and Markets

Radiators

Confectioners and Candy Manufacturers

Ovens
Corn poppers
Hot plates
Water urns
Cigar lighters
Stoves

Contractors and Builders

Glue pots
Soldering irons
Branding irons

Dairies and Creameries

Water boilers
Sterilizers
Stoves
Pasteurizers

Dentists

Dental furnaces
Vulcanizers
Water heaters
Sterilizers and cauterizers
Radiators

Department Stores

Kitchenettes for demonstration
Radiators
Irons
Cigar lighters
Pyrograph needles
Stoves

Drug Stores

Cigar lighters
Hot-water urns
Sterilizers
Radiators
Cauterizers

Dry Goods and Millinery

Curling-iron heaters
Flatirons
Radiators

Electrotypers

Melting pots
Water urns
Soldering irons
Solder pots
Heating furnaces

Engravers

irons	Solder pots

Factories

s	Solder pots
and branding irons	Welding

Farmers

s	Incubators
mers	Branding irons

Foundries

irons	Welders
ts	Small core ovens

Gas and Steam Fitting

irons	Solder pots
	Pipe-thawing apparatus

Grain Elevators

ring ovens

Hair Dressing

on heaters	Radiators
air dryers	Foot warmers
r urns	

Harness and Saddlery Shop

ers	Branding irons

Hat Stores and Hat Manufacturers

Hospitals and Sanitariums

ng devices	Sterilizers
pads	Baking cabinets
n coils	Electric light bath cabinets
s	Kitchen outfits (complete)

Hotels

on heaters	Heating pads
ax heaters	Cigar lighters
and tailors' irons	Kitchen outfits (complete)
s	Hot-water heaters
ght bath cabinets	

Jewelers and Opticians

Soldering irons

Solder pots

Laboratories

Ovens

Hot-water urns

Annealing furnaces

Laundries

Flatirons

Water boilers

Dryers

Electrically heated ironers mangles

Libraries

Book-branding devices

Sealing-wax pots

Glue pots

Lithographers

Matrix drying tables

Livery Stables

Electric forges

Branding irons

Lumber Dealers

Branding irons

Lunch Wagons and Stands

Kitchen outfits (complete)

Machine Shops

Soldering irons

Solder pots

Forges

Welders

Tool temperers

Brazier

Massage and Manicure Parlors

Curling-iron heaters

Hot-water urns

Radiators

Cauterizers

Offices

Sealing-wax heaters

Foot warmers

Hot-water b

Radiators

Cigar lighters

Office Buildings

:s

Oil-heating apparatus

Paper Box Manufacturers

ts

Sealing-wax heaters

Photographers

ts
rs

Burnishers
Electric dryers

Physicians and Surgeons

:ing devices
rs
light bath cabinets
cabinets

Hot-water urns
Heating pads
Radiators

Plumbers and Tinsmiths

g irons
ots

Pitch kettles for roofing
Pipe-thawing apparatus
Thawing transformers

Poultry Farms

ors

Brooders
Food warmers

Publishers and Job Printers

ts
drying tables
g irons
g irons
g and embossing presses

Sealing-wax heaters
Stoves for heating inks
Heaters for drying ink on cylinder presses
Monotype machines

Residences

stats for regulating fur-
ghters
ppers
milk warmers
pads
s

Chafing dishes
Flatirons
Curling-iron heaters
Foot warmers
Radiators
Kitchens (complete)

Restaurants

Coffee pots
Chafing dishes
Plate warmers
Radiators
Cigar lighters
Broilers (large size)
Griddles
Kitchen outfits (complete)

Roofers

Pitch kettles
Branding irons

Saloons

Water heaters
Plate warmers
Coffee percolators
Cigar lighters
Radiators

Schools and Colleges

Radiators
Pyrograph needles
Laboratory testing apparatu

Shirt and Overall Factories

Laundry and tailors' irons
Mangle rolls

Steel Mills and Blast Furnaces

Tool tempering apparatus
Steel furnaces
Welding

Street Railways

Car heaters
Track welders
Forges
Heated brake handles
Soldering irons
Solder pots

Tailors and Dressmakers

Laundry and tailors' irons

Tanneries

Hot wire for removing wool from skins

Telegraph and Telephone Companies

Soldering irons
Sealing-wax heater
Soldering pots

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SECTION 5

POWER ENGINEERING

SECTION 5

POWER ENGINEERING

INTRODUCTION

1. Technically speaking, **power signifies** the rate at which energy is transformed, independent of the nature of the transformation. The rate at which electric energy is transformed into light or heat is power just as well as that transformed into mechanical work in a motor, but the commercial engineer has established a custom of referring to service where motors are used as power service to distinguish it from heating and lighting service. It is in this sense that the title of this section is meant to apply.

2. It is not at all necessary for the **electrical solicitor** to understand what goes on inside the motor, or to study the theory of operation or design. **All he needs to know** are the general operating characteristics of the various types of machines, how to select the type and size of motor for a given service, and the advantages and limitations of each type under given working conditions. If he is interested to go farther into the subject, there are plenty of good books already on the market which cover the ground in a most complete manner.

ELECTRIC MOTORS

3. The electric motor is a device for transforming electric energy into mechanical energy. The principle upon which all motors operate is the force exerted between a magnetic field and a conductor carrying electric current.

4. Every **electric motor consists essentially** of a magnetic circuit and an electric circuit so arranged that one can move relatively to the other. The magnetic circuit is made of iron, which is a good conductor of magnetism and forms the frame of the stationary and rotating part of the machine.

The magnetism is produced by an electric current in coils of copper wire wound around a part of the magnetic circuit. These coils are usually on the stationary part of the machine.

5. The movable part, called the "armature" in direct-current motors and the "rotor" in alternating-current motors, is wound with another set of coils which carry the current that reacts with the magnetic field, thus producing the motion.

6. **Motors** are divided into two **classes**: direct-current and alternating-current, according to the system from which they are operated. The direct-current motors are subdivided into three classes, distinguished by the method of connecting the field and armature windings together; namely, series, shunt, and compound.

7. The **series motor** is one in which the armature winding and field winding are connected in series. It is a variable-speed motor; that is, its speed varies automatically with the load, increasing as the load decreases. Series motors are best adapted to intermittent service where heavy loads must be accelerated and brought up to full speed without an excessive instantaneous demand of energy. They are used on elevators, hoists, street cars, etc.

8. The **shunt motor** has its armature and field winding connected in parallel. It is a constant speed motor, regardless of the load; but its speed can be adjusted either by inserting resistance in series with the armature, which decreases the speed, or inserting resistance in the field circuit, which increases the speed. Inserting resistance in the armature wastes energy, while the method of inserting resistance in the field circuit is limited to a rather narrow range on account of sparking.

9. The **compound motor** is a combination of the series and shunt motor; that is, it has two distinct field windings, one in series with the armature, and the other in parallel with it. Its speed characteristics depend upon the relative value of the shunt and series windings. If the series winding preponderates, the characteristic will tend toward that of a series or variable-speed motor; while if the shunt preponderates, it will tend toward that of a shunt or constant-speed motor. The speed of a shunt machine drops off slightly *with increase* of load, so that by opposing the series winding

to the shunt winding, and properly choosing the number of turns, the speed can be held constant or made to rise with the load. In this case the motor is called a **differential motor**, to distinguish it from the compound.

10. The **operating characteristics** can best be explained when it is assumed that the reader has a general idea of the fundamental relations existing in the motor. A few of these relations are given below, and must be accepted as facts without proof, as it is entirely beyond the scope of this work to go into the theoretical side of the machines.

11. Let E be the voltage across the motor leads; I, the current in the armature, or load current; i, the current in the field winding; ϕ, the magnetic flux; S, the speed; P_i, the power input; P_l, the power loss; P_o, the power output; η, the efficiency; then the following **fundamental relations** for direct-current motors can be written: —

$$E = S \times \phi; \quad S = \frac{E}{\phi}.$$

Flux increases with the current i, but not in exact proportion. For convenience, we can write $\phi = i$, then —

$$S = \frac{E}{i};$$

$$P_i = E \times I; \quad P_o = P_i - P_l = P \times \eta.$$

12. From the equation it is seen that the **speed is determined** by just two things; namely, voltage of the supply and the field flux. All systems of direct-current motor speed control are accomplished by varying either one or both of these quantities.

13. The **supply voltage** can be **reduced**, and therewith the speed, by connecting a **rheostat in the armature circuit**, and when using the multiple wire system, several different supply voltages are available. Both of these methods are unsatisfactory and are seldom used. The rheostat method is wasteful of energy and is rarely used, except for series motors. **Examples of uses** to which this method can be satisfactorily applied are as follows: —

Printing presses	Air compressors
Print rolls	Paper machines
Plunger pumps	Blowers

Fans	**Conveyors**
Centrifugal pumps	**Bending rolls**
Hoists	**Cranes**

Speed control by **introducing a rheostat into the armat** circuit has also been tried in connection with **machine to** such as lathes, boring mills, etc., but has invariably resul disastrously. The condition imposed upon the motor d ing machine tools is one of constant power output through the entire speed range, and this condition cannot be when armature resistance is used.

14. A second important characteristic of the ideal mac tool motor is good **inherent regulation**; that is, comparati small decrease in speed from no load to full load. The ar ture resistance method of controlling the speed does not n these conditions, since the voltage losses in resistance creases directly with the load current for any given adj ment.

15. The **multiple wire system** is costly, and seldom av able; and even when available, the speed can only be va in two or three large steps.

16. There are two distinct **ways of varying the fi** one electrical and the other magnetic. The electric met consists in regulating the current in the field winding means of a field rheostat, while in the magnetic method reluctance or magnetic resistance of the motor is va by varying the air gap between the field poles and the mature. Examples of this system are the Stow and Linc motors.

17. The most widely used and most economical met is the one employing the **field rheostat**. By this method speed can be varied smoothly from its normal value up t point where the motor would fly to pieces. In practice t method is used on shunt and compound motors, but limited by sparking at the brushes to a rather small ra of speed variation.

18. The sparking is due to **armature reaction**, which an effect caused by the load current. The weaker field and the stronger the armature current, the greater armature reaction, and therewith the sparking. Armat reaction has been rendered harmless by the recent int *duction of the* **commutating pole**, also called auxiliary p

and inter-pole. The windings of these poles is connected in series with the armature so that their effect will be proportional to the armature current which causes the sparking. Shunt motors equipped with commutating poles have speed ranges as high as 6 to 1 and show no sign of sparking.

19. There are three classes of **alternating-current motors**: the induction motors, the synchronous motors, and the commutator motors.

20. The **induction motor** is a constant speed motor, being similar in its performance to a direct-current shunt motor. It is built in two distinct types, one with a short-circuited or squirrel-cage secondary, and the other with wound secondary.

21. The **squirrel-cage induction motor** is the most rugged and reliable electrical machine built, and wherever a constant speed is required, it is ideal. At starting it requires an excessive current, especially if it must start under full load; but if started with light load with a regular starter, the current is kept within a practical limit.

22. The **induction motor with wound secondary** is provided with slip rings, and resistance can be inserted in the secondary circuit. In some types a resistor is built within the motor itself, and in others it is external. The higher the resistance of the secondary, the less the starting current, and the greater the starting torque or force; but when running, the losses are greater, and therefore the efficiency less. Therefore, it is advantageous to have a high-resistance secondary when starting that can be reduced when running. The resistance in a secondary circuit decreases the running speed, and with it the efficiency of the motor. However, when it is absolutely necessary to vary the speed, this method is used, with the induction motor having a wound secondary.

23. The **synchronous motor** will not start under load, and must run at a speed fixed by the frequency of the system. The speed in revolutions per second equals the number of cycles per second, divided by half the number of poles; thus, a four-pole motor on a 60-cycle system will run at $60 \div 2 = 30$ revolutions per second, or 1800 revolutions per minute. *Due to the* unfavorable starting characteristic a *its constant speed,* the synchronous motor is seldom u

except where a large amount of power is required and the motor can run continuously.

24. **Alternating-current commutator motors** are new, and only a few are as yet on the market. At present they are used almost exclusively for traction purposes, and in very small sizes on fans, vibrators, etc. Undoubtedly, they will be introduced for general variable speed work at an early date. The alternating-current commutator motor is ideal for variable speed work, since the voltage across the motor, and therewith the speed, can be varied from zero to any desired value by the use of a transformer with taps brought out from the secondary, which method has the advantage of entailing practically no loss of energy.

THE CHOICE OF MOTORS

25. It is of the utmost importance to users of electric motors that the machines purchased be not only of high efficiency, but of the proper size and winding to perform the work in hand. While it is well always to purchase a motor having a small **margin of power** above actual requirements, it is not desirable to buy one much larger than is needed, unless additional load is to be taken on in the immediate future.

26. The best motors are so designed that they possess maximum efficiency for continuous running at their normal rated output, and it should be the aim to so subdivide the grouping of machinery that the motors in use may, so far as possible, operate at their maximum output when running at all.

27. In equipping a factory a number of machines will often be found which are used intermittently. As a rule, it is not desirable to drive such machines from motors that are operating other machinery continuously, for if this is done, then during certain periods, when the intermittently used machines are idle, the motor will be **working at partial load** and at a point much below its best efficiency. Only during a portion of the time, when the machines intermittently used are at work, will the motor be carrying its full load, and doing its work in the most economical manner.

28. In cases where a **mixed load** must be carried it is desirable to split the drive and use two or more motors, one for driving the continuously operated machines, and the other for driving those which are intermittently operated. In this way each motor may be worked at its best efficiency, when working at all, and a large saving in energy bills will result.

29. There are many branches of industry in which some machines are operated continuously ten hours per day, and in the same shop there may be others which are only operated one or two hours per day. The work may usually be so arranged that the machines necessitating intermittent operation can be used without throwing them all on at the same time. Under these circumstances a comparatively small motor running at high efficiency may be used for all of these machines, through the intermediary of a short length of shafting.

30. The choice of the type of motor to be used is also largely influenced by the work to be done. Pure **shunt wound motors** have very good regulation, under various fluctuations of load, after they are once brought up to speed, and if the machines to be operated are well balanced, are doing reasonably uniform work, and have no very heavy moving parts, the inertia of which must be overcome in bringing them up to speed, shunt wound motors are applicable.

31. The shunt wound motor, when used to bring a very heavy piece of machinery into motion quickly, where large inertia must be overcome, labors under a great disadvantage, inasmuch as it cannot exert such abnormal starting torque as can the **compound wound motor.** In the case of those machines which operate under sudden and intermittent loads, or which have parts whose inertia requires the expenditure of much energy to overcome, compound wound motors are better, although their speed regulation is not equal to that of shunt motors in general. A failure to give due weight to these considerations has often resulted in the failure to get that satisfaction out of the electric drive which can always be accomplished when proper motors are chosen. Wood-working machinery, — with the exception of large rotary saws, — screw machines, engine and speed lathe

shapers, drills, and similar machines can usually be operated successfully with shunt wound motors; while punches, large shears, drop hammers, planers, many classes of cooperage machinery, the larger printing presses, etc., can be operated more satisfactorily if the motor is compound wound. Cranes, hoists, and winches are usually equipped with straight **series wound motors.**

32. It is of great importance to **central stations** that motors of proper adaptability and high **efficiency** be purchased by their customers, — other things being equal, — for the lower the customer's energy bills are, the more he will be justified in using central station service, and the more attractive a proposition to displace his engines and boilers, or power rented from some line shaft, can be made.

33. As a rule, motor solicitors, while understanding this general principle, do not take pains enough to enforce its consideration on the prospective customer. They tell him, in glittering generalities, that the purchase of an efficient motor will result in smaller energy bills than the purchase of an inefficient motor, but they rarely figure out to the customer just why, or to what extent, this is so, and the customer, having no knowledge of the matter for himself, does not give that weight to the general statement which it is entitled to receive.

34. It is an easy matter to show the **financial aspect** of a small saving in **motor efficiency**, and for those who are unfamiliar with the method of working out a comparison, the following example is given: a 10-hp. motor with an efficiency of 100 per cent will take $10 \times 746 = 7460$ watts at full load, and $5 \times 746 = 3730$ at half load. If the efficiency be 85 per cent at full load and 75 per cent at half load, it will take $746 \div 0.85 = 8780$ watts, and $3730 \div 0.75 = 4970$ watts, respectively. Now, for the sake of comparison, assume another motor of the same rating with an efficiency of 75 per cent at full load and 65 per cent at half load, then the corresponding assumptions are $7460 \div 0.75 = 9950$, and $3730 \div 0.65 = 5740$, respectively. The difference in consumption between the two motors at full and half load are $9950 - 8780 = 1170$ watts, and $5740 - 4970 = 770$ watts, respectively. Working 10 hours a day, 300 *days per year,* with electric energy 10 cents per kilowatt-

hour, a saving of one of these motors over the other would be, full load: —

$$1170 \times 10 \times \frac{300}{1000} = 3510 \text{ kw-hr.},$$

$$3510 \times 0.10 = \$351 \text{ per year;}$$

half load: —

$$770 \times 10 \times \frac{300}{1000} = 2310 \text{ kw-hr.},$$

$$2310 \times 0.10 = \$231 \text{ per year.}$$

35. Capitalized, the results are the same from an income standpoint as if the owner of the more efficient motor had laid away $7000 at 5 per cent per annum interest; or, in other words, the owner of the less efficient motor is actually paying a premium of 5 per cent per cent per annum on an investment of $7000 for the privilege of operating a rather poor machine with an extravagant appetite for electric energy. The purchase and use of inefficient motors may lead to disputed bills and dissatisfied motor users.

36. Saving in Dollars for Differences in Efficiency, Energy at 5 ct. per kw-hr., Motor working at Full Load 10 hr. per Day for 312 Days

Size of Motor Hp.	Per Cent Difference in Efficiency at Full Load									
	1	2	3	4	5	6	7	8	9	10
1	1.16	2.33	3.49	4.66	5.82	6.98	8.15	9.31	10.47	11.64
2	2.33	4.66	6.98	9.31	11.64	13.97	16.29	18.62	20.95	23.28
3	3.49	6.98	10.47	13.97	17.46	20.95	24.44	27.93	31.42	34.91
5	5.82	11.64	17.46	23.28	29.10	34.91	40.73	46.55	52.37	58.19
7.5	8.73	17.46	26.19	34.92	43.64	52.37	61.10	69.83	78.56	87.28
10	11.64	23.28	34.91	46.55	58.19	69.83	81.46	93.10	104.74	116.38
15	17.46	34.92	52.37	69.83	87.28	104.74	122.20	139.65	157.11	174.56
20	23.28	46.55	69.83	93.10	116.38	139.65	162.93	186.20	209.48	232.75
25	29.09	58.19	87.28	116.38	145.47	174.56	203.66	232.75	261.85	290.94
30	34.91	69.83	104.74	139.65	174.56	209.48	244.39	279.30	314.22	349.13
35	40.73	81.46	122.20	162.93	203.66	244.39	285.12	325.85	366.58	407.32
40	46.55	93.10	139.65	186.20	232.75	279.30	325.85	372.40	418.95	465.50
50	58.19	116.38	174.56	232.75	290.94	349.13	407.32	465.50	523.69	581.88

THE APPLICATION OF MOTORS TO MACHINE TOOLS

37. The conditions under which machine **tools** operate are so varied that it is impossible to represent by **empirical formulas** the exact horsepower which should be used. The formulas given in paragraphs **45** to **63** are based on the assumption that water-hardened tool steel is used at an average **cutting speed** of approximately 20 ft. per minute.

38. Where **high-speed tool steels** are used, the horsepower required by the machine will increase approximately in direct proportion to the increase in cutting speed.

39. Broadly speaking, the **machine tools** may be divided into two **classes**; namely, those with direct rotary motion of either work or tool, and those with a reciprocating motion of either work or tool. The first class comprises lathes, boring mills, milling machines, drill presses, etc., while the second class includes planers, shapers, slotters, and machines of similar character.

41. Under abnormal conditions of either machine or work, the formulas in paragraphs **45** to **63** will give horsepowers smaller than those which should be applied. Such conditions, however, must be considered as abnormal and motors specified with this point in view.

42. The **adjustable speed motor** has decided advantages in the way of economical production when applied to machine tools. With the old method of **speed variation**, that is, by means of **cone pulleys** or **nests of gears**, only coarse increments in speed are obtainable, which invariably means that the machine tool cannot be worked up to the limit of its producing capacity.

43. With the new high-speed steels necessitating greater pulling power from the belts and increased strength in the gears, reasonably fine increments in speed are almost impossible, due to the great length of the cone pulleys or the abnormally large size of the change gears required to obtain the necessary range of speed variation. The adjustable speed motor actually decreases the cost of machine tool by eliminating the bulky and expensive speed change devices.

44. Machines having Rotary Motion.[1] — In general, motors to be used for lathes, boring mills, drill presses, etc., should be of the shunt wound adjustable speed type with good inherent speed regulation. The following formulas give a rough idea of the amount of power required by various machines.

45. Engine lathes using one cutting tool of water-hardened steel at about 20 ft. per minute: —

Horsepower $= 0.15\,S - 1$.
Heavy engine lathes, such as forge lathes.
Horsepower $= 0.234\,S - 2$.
In all cases, S = swing of lathe in inches.

46. For the operation of standard **boring mills**, using one cutting tool of water-hardened steel at approximately 20 ft. per minute, the following formula will be found to represent good practice for heavy work: —

Horsepower $= 0.25\,S - 4$.
Where S = swing of mill in inches.

47. For normal **milling machines**, using water-hardened steel cutters running at about 20 ft. per minute, the following formula will be found useful: —

Horsepower $= 0.3\,W$.
Where W = distance between housings in inches.

48. For normal **drill presses**, using water-hardened steel drills, running at a peripheral cutting speed of approximately 20 ft. per minute: —

Horsepower $= 0.06\,S$.

For heavy radial drill presses: —

Horsepower $= 0.1\,S$.
Where S = swing of drill in inches.

49. In general, if high-speed tools are used, running at a higher cutting speed than those given, the increase in horsepower should be approximately proportional to the increase in speed.

50. Machines having Reciprocating Motion. — Machines of this character are from their nature less productive than

[1] *Practice of* Westinghouse Electric Manufacturing Company.

machines having a purely rotary motion of either cutter or work. For this reason it is especially important that machines having a reciprocating motion be run to the limit of their capacity.

51. This, of course, requires an adjustable speed motor, similar to the motor described in connection with rotary motion machines, except that in the case of machines having a reciprocating motion the **compound wound motor** should be invariably used. The compound wound motor is useful in that at the instant of reversal of the machine tool, when the torque required of the motor increases very considerably above the normal, the compound winding assists materially in holding the inrush of current within reasonable limits; and this may be further improved by the use of the fly wheel.

52. The following figures show average practice, so far as horsepower required for operation of some of the typical reciprocating machines is concerned.

53. Normal **crank slotters**, using water-hardened steels at cutting speeds of from 15 to 20 ft. per minute: —

Stroke	Horsepower
10 inches	5
18 inches	7
30 inches	10

54. **Shapers**, using water-hardened tool steels at cutting speeds of from 15 to 20 ft. per minute: —

Stroke	Horsepower
16 inches	3
18 inches	3.5
24 inches	5
30 inches	6.5

55. For normal **planers**, using water-hardened steel at cutting speeds of from 15 to 20 ft. per minute. By normal planer is meant a planer in which the length of the bed in feet is approximately two tenths the width between the housings in inches. For example, a 48-in. planer would have a length of platen of approximately 9.6 or 10 ft.

Horsepower = $3W$.
Where W = width between housings in feet.

For heavy forge planers: —

Horsepower = [illegible].92 W.

56. The above formulas are for planers having a **ratio of cutting to return speeds** of approximately 1 to 3, and cover planers with two tools in operation. If more than two tools are used, or if the ratio between the forward and return speeds is more than 1 to 3, the horsepower given by above formula should be increased.

57. It should be noted that where the length of bed is greater than that mentioned above, the horsepower should be increased. It is a singular fact that the horsepower specified in connection with planers is determined more by the current inrush at the instant of quick reverse than by the horsepower required to actually machine the metal. In an extensive series of tests it was shown that invariably the horsepower at quick reverse is the deciding factor. It is dangerous to greatly overload the motor at the instant of quick reverse for the reason that under some conditions, as, for example, on very short stroke, the overload on the motor may be fairly continuous, and experience indicates that motors for operating planers should be rather more liberally rated than those for almost any other machine tool application.

58. In connection with lathes, boring mills, milling machines, drill presses, slotters, and shapers it has been found necessary to devise empirical formulas, which represent the **horsepower required by the cutting tool** as a function of the metal removed. These formulas have been extremely useful and show an astonishing agreement with tested results where the quality of material is known. On account of the variations in the quality of the material, however, they are not of general application.

59. The action of a **twist drill** is peculiar, in that aside from the actual cutting action there is more or less of a binding action between the drill and the side of the hole. The formula connecting the horsepower with the other variables is as follows: —

$$\text{Horsepower} = (K \times \text{cu. in. per minute} + L)\frac{\times\, r.p.m.}{100}$$

K is the empirical constant, as is also L. L, however, is entirely rational, in that it represents the friction of the drill *on the side of the hole.*

60. It has also been found that when drilling horizontally, approximately 20 per cent less power is used than in the case of vertical drilling, owing to the fact that the drill clears itself of chips much more readily. This is particularly true in the case of cast iron.

61. It has been found that the formulas connecting the horsepower at the tool with the known variables in the case of **lathes, boring mills**, etc., assumed the following form:—

$$\text{Horsepower} = L \times A \times V \times (C - r)$$

62. In which L is the empirical constant, A is the area of the cut in square inches, V is the cutting speed in feet per minute, C is the included angle of the tool, *i.e.* 90 deg.— (the rake plus the clearance), and r is a second empirical constant. It has been found that after the material has once been determined, this formula is correct to within 10 per cent. The above formula applies particularly to **wrought iron and steel**. The formula for cast iron is considerably more complicated, and for approximate working the above formula may be used. The constants depend entirely upon the character of material being machined — its hardness, its heat treatment, etc., and it will be of little use to give these constants here.

63. Aside from the **horsepower** required **at the tool**, whether it be a lathe tool or drill, it is necessary to obtain a definite idea as to the horsepower required to operate the various machine tools when running light. It has been found from an extensive series of tests that this horsepower varies widely, and it is therefore practically necessary in each case to make a study of the machine to be motor driven. The above formula may be useful in approximating the horsepower required under given conditions, but it has been found that it is impossible to derive any formula which will take account of all of the operative conditions, and the results given by the formula must invariably be tempered by judgment, based on the character of the work, personnel, and numerous other factors.

70. TESTS OF POWER TAKEN BY LATHES USING VICKERS' HIGH-SPEED TOOL STEEL

Size lathe cent. in.	Material	Cutting speed ft. per min.	No. of tools	Lbs. of metal per hour	Cut. in.	Traverse in.	Hp.	Lb. of metal per Hp.-hr.
36	Gun steel	13	1	187	0.38	0.166	9	21
36	Gun steel	21	1	280	0.38	0.166	15.4	18.2
36	Gun steel	32	1	360	0.26	0.166	15.4	23.4
36	Gun steel	12	4	460	0.28	0.166	19.8	23.2
36	Gun (very hard)	8	4	110	0.50	0.143	15	7.33
36	Gun steel ingot	51	1	502	0.99	0.05	25.5	19.7
36	Gun steel ingot	48	1	570	0.58	0.10	33	17.3
36	Marine shaft (32 tons tensile)	50	1	480	0.50	0.10	22	21.8
40	Marine shaft	13.5	8	900	0.30	0.25	39	23.0
30	Gun steel	18	2	795	0.45	0.188	30	26.5

71. TESTS ON A 30-INCH VERTICAL BORING MILL

Weight on table, 90-lb. back gear in.	Power taken by various cuts in cast steel				
	Cut $\frac{3}{16}$ in. × $\frac{1}{64}$ in. cut at 4.625 in. radius.			Cut $\frac{3}{16}$ in. × $\frac{1}{32}$ in. cut at 4.625 in. radius.	
	Speed ft. per min.	Motor output hp.	Metal removed cu. in. per min.	Motor output hp.	Metal removed cu. in. per min.
TABLE SPEED — 12.5 r.p.m.					
Cutting	31.5	1.04		2.60	
Not cutting		0.35		0.35	
Power consumed in cutting		0.69	1.11	2.25	2.22
TABLE SPEED — 11 r.p.m.					
Cutting	27.25	0.88		1.85	
Not cutting		0.34		0.34	
Power consumed in cutting		0.54	0.96	1.51	
TABLE SPEED — 10 r.p.m.					
Cutting	24.22	0.75		1.60	
Not cutting		0.30		0.30	
Power consumed in cutting		0.45	0.85	1.30	1.70
TABLE SPEED — 8.5 r.p.m.					
Cutting	19.38	0.63		1.42	
Not cutting		0.29		0.29	
Power consumed in cutting		0.34	0.68	1.13	1.36
TABLE SPEED — 6 r.p.m.					
Cutting	15.14	0.46		1.08	
Not cutting		0.28		0.28	
Power consumed in cutting		0.18	0.53	0.80	1.06

71. *(Cont.)* POWER TAKEN BY VARIOUS CUTS IN FORGED STEEL

WEIGHT ON TABLE, 75-LB. BACK GEAR IN.	CUTTING TOOLS		MOTOR OUTPUT	METAL REMOVED CU. IN. PER MIN.
	Speed ft. per min.	Cut inches	hp.	
TABLE SPEED — 14 r.p.m.				
Not cutting			0.37	
Cutting	17.7	$\frac{1}{8} \times \frac{1}{64}$	0.63	0.4
Cutting	33.2	$\frac{13}{32} \times \frac{1}{64}$	1.77	2.5
TABLE SPEED — 12.5 r.p.m.				
Not cutting			0.35	
Cutting	23.5	$\frac{13}{32} \times \frac{1}{64}$	1.49	1.8
Cutting	22	$\frac{29}{64} \times \frac{1}{64}$	1.43	1.9
Cutting	22	$\frac{5}{8} \times \frac{1}{64}$	2.22	2.6

71. *(Cont.)* POWER TAKEN BY VARIOUS CUTS IN SOFT CAST IRON

WEIGHT ON TABLE, 90-LB. BACK GEAR IN.	CUTTING TOOLS		MOTOR	METAL REMOVED CU. IN. PER MIN.
	Speed ft. per min.	Cut inches	hp.	
TABLE SPEED — 6 r.p.m.				
Not cutting			0.28	
Cutting	34.4	$\frac{1}{8} \times \frac{1}{16}$	1.14	3.2
Cutting	32.7	$\frac{5}{16} \times \frac{1}{24}$	2.92	5.1
TABLE SPEED — 5 r.p.m.				
Not cutting			0.26	
Cutting	27.5	$\frac{8}{16} \times \frac{1}{16}$	1.10	3.9
Cutting	26.16	$\frac{5}{16} \times \frac{1}{24}$	2.36	4.1
TABLE SPEED — 4 r.p.m.				
Not cutting			0.23	
Cutting	22	$\frac{3}{16} \times \frac{1}{16}$	0.90	3
Cutting	20.9	$\frac{5}{16} \times \frac{1}{24}$	1.58	3.3
Cutting	34.4	$\frac{3}{16} \times \frac{1}{32}$	1.24	2.4
Cutting	34.4	$\frac{3}{16} \times \frac{1}{64}$	0.54	1.2

71. (*Cont.*) Power taken by Heavy Cuts in Soft Cast Iron

Weight on table, 600-lb. back gear in.	Cutting Tools		Motor Output	Metal removed cu. in. per min.
	Speed ft. per min.	Cut inches	hp.	
Not cutting — $5\frac{1}{2}$ r.p.m.			0.27	
Cutting — $5\frac{1}{2}$ r.p.m.	34.5	$\frac{9}{16} \times \frac{1}{32}$	2.75	7.3
Cutting — 5 r.p.m.	28.8	$\frac{9}{16} \times \frac{3}{64}$	4.07	9.1
Cutting — $4\frac{3}{4}$ r.p.m.	31	$\frac{11}{16} \times \frac{1}{32}$	4.20	8
Cutting — $4\frac{1}{4}$ r.p.m.	27.8	$\frac{7}{8} \times \frac{1}{32}$	5	9.1

72. Tests on a 10-ft. Radial Drill

Power Required for Drilling

Work	Drill		Motor Output Hp.	Metal Removed Cu. In. per Min.
	Speed r. p. m.	Feed in. per rev.		
Soft Cast Iron				
$1\frac{1}{4}$-in. twist drill	45	0.0055	0.9	0.31
	45	0.0139	1.14	0.77
$1\frac{1}{2}$-in. twist drill	30	0.0139	2.12	1.11
	70	0.0029	1.80	0.37
2-in. twist drill	30	0.0135	1.07	1.27
	45	0.0139	2.53	1.96
Hole, 5-in. deep, $2\frac{1}{4}$-in. twist drill	30	0.0083	0.98	0.99
Hole, $5\frac{1}{4}$-in. deep, $2\frac{1}{4}$-in. twist drill	30	0.012	1.47	1.48
With back gear, $3\frac{3}{4}$-in. twist drill	11	0.0170	2.35	2.06
Medium Cast Steel				
Maximum safe cut, $2\frac{1}{8}$-in. twist drill	30	0.0135	2.45	1.43
$2\frac{5}{16}$-in. twist drill	30	0.0076	1.87	0.96
Ordinary practice, $2\frac{1}{2}$-in. twist drill	30	0.0072	2.10	1.07
$2\frac{3}{4}$-in. twist drill	30	0.0072	2.45	1.29

72. Tests on 10-ft. Radial Drill (*Continued*)

Machine Steel

$1\frac{1}{2}$-in. twist drill	45	0.0028	1.60

Babbit Metal

2-in. twist drill	30	0.0083	.080

Power Required for Counterboring

Soft Cast Iron

$1\frac{1}{4}$-in. pilot hole, $2\frac{1}{4}$-in. facing bar	45	0.0083	1.27
$1\frac{3}{4}$-in. pilot hole, $2\frac{1}{4}$-in. facing bar	45	0.0083	1.37
$1\frac{1}{8}$-in. pilot hole, $2\frac{1}{16}$-in. facing bar	30	0.0083	1.80
2-in. pilot hole, $3\frac{1}{4}$-in. facing bar	30	0.0083	1.14

Medium Cast Steel

$2\frac{3}{8}$-in. pilot hole, $4\frac{1}{2}$-in. facing bar (back-geared)	8	0.0136	2.65

Cast Steel

$2\frac{1}{2}$ in. pilot hole, $4\frac{1}{2}$-in. facing bar (back-geared)	8	0.0078	1.90

73. Rating of Motors Required for Different Presses, Punches, etc.[1]

Machine	Hp. of Motor	Machine	Hp. of Motor
PG 6 Ferracute press	7.50	Bliss No. 105 circular shear	0.50
SG 86 Ferracute press	5	Bliss No. 105½ circular shear	1
C 5 Ferracute press direct geared	3	Bliss 36-in. geared power shear, 1¼-in. sheet steel	5
P 21 Ferracute press 18 in. throat direct geared	2	Bliss-Stiles No. 0 fly wheel punching press	0.50
DG 56 Ferracute drawing press	10	Bliss-Stiles No. 1 fly wheel punching press	0.50
P 3 Ferracute press	3	Bliss-Stiles No. 2 fly wheel punching press	1
P 2 Ferracute notching press	1	Bliss-Stiles No. 3 fly wheel punching press	2
C 92 Ferracute notching press	1	Bliss-Stiles No. 4 fly wheel punching press	3
E 4 Ferracute press roll feed attached	3	Bliss-Stiles No. 5 fly wheel punching press	4
Bliss No. 18 fly wheel press	0.50	Bliss-Stiles No. 5 press geared on heavy work	5
Bliss No. 19 fly wheel press	1	Bliss-Stiles No. 172 sprue cutter fly wheel	2
Bliss No. 20 fly wheel press	1	Bliss-Stiles No. 173 sprue cutter fly wheel	2
Bliss No. 21 fly wheel press	2	Bliss-Stiles No. 200 automatic board lift drop	3
Bliss No. 52 fly wheel press	2	Bliss-Stiles No. 400 automatic board lift drop	4
Bliss No. 30 press geared	3	Bliss-Stiles No. 800 automatic board lift drop	7.50
Bliss No. 36 press geared	5	No. 2 Hilles and Jones combined punch and shear	5
Bliss No. 32 double crank press geared	5	No. 3 Hilles and Jones combined punch and shear with 36-in. throat punching 1½-in. hole through 1-in. cast iron	10
Bliss No. 5 double crank press geared	7.50		
Bliss No. 47½ press geared	1		
Bliss No. 74½ press geared with side cut off slide	4		
Bliss No. 1½ toggle drawing press	5		
Bliss No. 3½ toggle drawing press	5		
Bliss No. 68 N fly wheel drawing press and roll feeds	2		
Bliss No. 102 cut and carry gang press geared	3		

[1] Motors for press work should in all cases be compound wound, and constant care must be exercised in starting on account of the fly wheel, which makes it possible to get an extremely heavy inrush of current during the acceleration period.

74. Power Required to Drive Wood-working Machinery

	Speed of tool R.P.M.	Ft. per min. of tool	Material	Dimensions in inches			Hp. no load	Max. hp. to start	Hp. to drive
				Thickness of material	Width of cut	Depth of cut			
10-in. Circular Rip Saw, Belted to 5-hp. motor	2640	6920	Pine	—	—	.75	2.9	5.2	3.2
	2640	6920	Maple	—	—	1.25	2.9	5.2	3.5
10-in. Circular Rip Saw, Belted to 5-hp. motor	2100	5497	Spr. (wet)	—	—	2	1.3	6	8
14-in. Circular Cut-off Saw, Belted to 7.5 hp. motor	2100	7696	Ash	—	—	3	2.6	7.3	9.3
	2100	7696	Spruce	—	—	2	2.6	7.3	8.7
17-in. Circular Rip Saw, Belted to 7.5 hp. motor	2150	9567	Spruce	—	—	3	2.6	10.7	9.3
	2150	9567	Spruce	—	—	1	2.6	10.7	4
18-in. Circular Rip Saw, Belted to 7.5 hp. motor	2100	9895	Ash	—	—	7	1.3	15.4	10.2
18-in. Cut-off Saw	2100	9895	Ash	—	—	4	1.3	15.4	9
12-in. Circular Saw, Belted to 5-hp. motor [1]	2915	9165	Ash	—	—	2.5	1.5	6.3	5.7
Jig Saw, Belted to 3-hp. motor [2]	—	—	Ash	4	—	—	—	3.2	1.1
	—	—	Ash	1	—	—	—	3.2	1
S. A. Wood Band Saw, Belted to 3-hp. motor	—	3720	Spruce	6	—	—	1.2	5.1	2.6
	—	3720	Spruce	2	—	—	1.2	5.1	1.9
	—	3720	Lignum-vitae	3½	—	—	1.2	5.1	3.2
S. A. Wood 16-in. Buzz Planer, Belted to 5-hp. motor	4000	5230	Ash	—	11.5	6	1.5	6.3	10
	4000	5230	Ash	—	11.5	8	1.5	6.3	10.7
S. A. Wood 24-in. Buzz Planer, Geared to 5-hp. motor	4000	6282	Ash	—	13	4	—	—	3.6
	4000	6282	Ash	—	13	6	—	—	3.8
	4000	6282	Ash	—	13	8	—	—	4.2
	4000	6282	Ash	—	13	10	—	—	4.5
	4000	6282	Maple	—	2	4	—	—	2.1
	4000	6282	Pine	—	2.5	4	—	—	2.1
J. A. White 15-in. Cylinder Planer, Belted to 7.5-hp. motor	3675	4820	Hickory	—	3	6	3	8.1	6.3
	3675	4820	Pine	—	6	10	3	8.1	5
	3675	4820	Pine	—	6	8	3	8.1	3.6
S. A. Wood 24-in. Cylinder Planer, Belted to 7.5-hp. motor. See Note at end	3725	4800	Spruce	—	6	6	3	10.7	4.1
	3725	4800	Spruce	—	18	6	3	10.7	8.2
	3725	4800	Spruce	—	24	6	3	10.7	12.3
	3725	4800	Spr. (wet)	—	12	4	3	10.7	18
	3725	4800	Pine	—	14	4	3	10.7	6.7
	3725	4800	Pine	—	8	8	3	10.7	7.3
	3725	4800	Pine	—	8	12	3	10.7	8.7
	3725	4800	Ash	—	6	16	3	10.7	9.3
	3725	4800	Ash	—	20.5	5	3	10.7	15.4
	3725	4800	Ash	—	20.5	4	3	10.7	12.7

[1] 2 saws in parallel on same arbor.

[2] *Length of stroke*, 4 in.; 6 horsepower required to drive countershaft of this *machine.*

74. Power Required to Drive Wood-working Machinery (*Cont.*)

	Speed of tool R.P.M.	Ft. per min. of tool	Material	Dimensions in inches: Thickness of material	Dimensions in inches: Width of cut	Dimensions in inches: Depth of cut	Hp. no load	Max. hp. to start	Hp. to drive
J. A. Fay Double Head Irregular Molder, Each Head belted to 3-hp. motor	4800	5024	Ash	——	.5	——	1.1	3.8	1.2
	4800	5124	Maple	——	2	——	1.1	3.8	1.8
S. A. Wood 24-in. Cylinder Planer, Geared to 7.5-hp. motor	4000	5240	Ash	——	13	4	2.4	9.2	5.7
	4000	5240	Ash	——	13	8	2.4	9.2	7.2
	4000	5240	Pine	——	14	4	2.4	9.2	5.5
	4000	5240	Pine	——	8	8	2.4	9.2	5.2
	4000	5240	Pine	——	8	12	2.4	9.2	7
Am. Wood Mfg. Mach. Co., 4-sided Molder, Belted to 10-hp. motor; 2 Knives and Heads Running	——	——	Ash	2	1	1.5	5.2	10.4	10.4
Same Machine with 4 Knives and Heads Running	——	——	Ash	1.25	Light	——	6.7	15.6	9.3
8-in. Circular Rip Saw Belted to 5-hp. motor	1975	4136	Hickory	——	——	1.5[1]	1.6	6.9	3.2
	1975	4136	Pine	——	——	1	1.6	6.9	2.4
8-in. Circular Rip Saw Belted to 5-hp. motor	3140	6575	Spruce	——	——	2[1]	1.6	6.9	3.8
8-in. Circular Cut-off Saw Belted to 5-hp. motor	2700	5651	Maple	8	——	.5	1.9	6.9	2.4
	3040	6366	Maple	——	——	1	1.9	6.9	3.8
8-in. Dado Circular Slit Saw Belted to 5-hp. motor	2515	5266	Pine	.5	——	1.9	2.4	5	5
8-in. Circular Cut-off Saw Belted to 5 hp. motor	2760	5797	Mahogany	——	——	1	1.6	5.8	2.8
8-in. Circular Cut-off Saw (Saw Dull), Belted to 5-hp. motor	2760	5797	Pine	——	——	.875	1.6	5.8	3.5
10-in. Circular Rip Saw, Belted to 5-hp. motor, Fed Hard	2100	5497	Hickory	——	——	2.5	1.7	6.4	7.3
			Hickory	——	——	2.5	1.7	6.4	5.4
Fed Easy		5497	Hickory	——	——	.5	1.7	6.4	2.7
10-in. Circular Cut-off Saw Belted to 5-hp. motor	2450	6413	Maple	——	——	2	1.6	6.4	2.5
	2450	6413	Spruce	——	——	1	1.6	6.4	1.9

Note. — In the test of the 24-in. cylinder planer, 2000 feet of 3-in. spruce, rough plank, was put through on a continuous run of 1½ hours. The cut varied 0.125 to 0.25, and the planks from 6 in. to 10 in. in width. Readings taken every five minutes gave an average of 11.9 hp.

[1] Thickness of lumber

FANS AND BLOWERS

80. [illegible] procure fresh air and to keep it in circulation is [illegible] of particular interest to those who are compelled [illegible] temporarily or permanently indoors. In sum- [illegible] ially, and in inland and low sections of the coun- [illegible] angements for good ventilation become a matter of [illegible] necessity to render a store, shop, or factory even [illegible] during the hot months, and in the winter it is [illegible] important matter where a large number of people [illegible] as in audience rooms, banquet halls, clubs,

[illegible] ventilation it is not only necessary to draw [illegible] but to remove the vitiated air, and to continue [illegible] indefinitely. For many industrial purposes, [illegible] desired object is to remove moist air from [illegible] lumber, cloth, paper, tobacco, or other ar- [illegible] merchandise are being dried, to exhaust those nox- [illegible] fumes which attend certain processes of manu- [illegible] a circulation of air over heated or cooled [illegible] maintaining equable temperature in assembly [illegible] ments. Though this was not formerly an [illegible] accomplish, apparatus is now obtainable [illegible] produce the required results.

[illegible] fan of the **propeller type** is usually fixed [illegible] in the wall and can be arranged as [illegible] draw in fresh air or expel bad. An [illegible] be placed so that it discharges the air [illegible] as the prevailing wind, in order to [illegible] with wind pressure. The number [illegible] **inlets** and probable effects of prevailing [illegible] be considered carefully in determin- [illegible] Under ideal conditions the room [illegible] have only one inlet for air which [illegible] end of the room from the exhaust [illegible] to be installed, of course, depends [illegible] conditions, but roughly speaking, the [illegible] sufficient to provide fresh air for [illegible] allows for the provision of 2000 [illegible] for each occupant of the room.

83. Capacity, Speed, and Horsepower of Disk Ventilating Fans
(American Blower Co.)

Air Velocity in Feet per Minute		Size Fan	Inches 18	21	24	30	36	42	48
600	Free	Cu. ft. p. min.	1060	1440	1880	2940	4230	5772	7536
		Rev. per min.	327	280	245	196	165	140	122
		Hp.	0.016	0.022	0.028	0.048	0.064	0.087	0.113
	Heater	Rev. per min.	530	453	396	317	267	227	197
		Hp.	0.053	0.072	0.094	0.147	0.212	0.288	0.377
700	Free	Cu. ft. p. min.	1235	1680	2200	3400	4940	6730	8800
		Rev. per min.	370	328	280	230	190	164	145
		Hp.	0.025	0.035	0.045	0.070	0.110	0.136	0.178
	Heater	Rev. per min.	600	530	458	372	307	266	234
		Hp.	0.071	0.096	0.126	0.196	0.283	0.384	0.503
800	Free	Cu. ft. p. min.	1410	1920	2510	3820	5650	7700	10300
		Rev. per min.	435	373	326	262	218	187	164
		Hp.	0.036	0.048	0.068	0.098	0.142	0.192	0.251
	Heater	Rev. per min.	705	604	527	424	353	302	265
		Hp.	0.106	0.149	0.189	0.194	0.426	.579	0.756
900	Free	Cu. ft. p. min.	1584	2160	2826	4410	6354	8650	11304
		Rev. per min.	490	425	368	285	246	210	184
		Hp.	0.048	0.065	0.085	0.132	0.190	0.258	0.338
	Heater	Rev. per min.	792	770	595	461	398	340	298
		Hp.	0.143	0.195	0.254	0.397	0.572	0.780	1.02
000	Free	Cu. ft. p. min.	1770	2400	3140	4900	7060	9610	12560
		Rev. per min.	545	470	406	328	275	234	205
		Hp.	0.057	0.080	0.104	0.142	0.233	0.317	0.413
	Heater	Rev. per min.	883	760	657	530	445	378	332
		Hp.	0.204	0.276	0.362	0.565	0.814	1.11	1.45
200	Free	Cu. ft. p. min.	2112	2880	3768	5880	8472	11541	15072
		Rev. per min.	654	560	490	398	330	280	245
		Hp.	0.101	0.138	0.180	0.280	0.405	0.550	0.716
	Heater	Rev. per min.	1059	912	788	636	534	453	396
		Hp.	0.300	0.409	0.534	0.832	1.20	1.64	2.14
400	Free	Cu. ft. p. min.	2475	3360	4400	6850	9870	13470	17600
		Rev. per min.	767	655	570	460	388	327	286
		Hp.	0.133	0.180	0.235	0.368	0.530	0.721	0.942
	Heater	Rev. per min.	1235	1064	919	742	623	528	463
		Hp.	0.487	0.660	0.864	1.35	1.95	2.64	3.46
600	Free	Cu. ft. p. min.	2830	3850	5000	7810	11300	15400	20050
		Rev. per min.	875	750	656	526	438	375	332
		Hp.	0.185	0.252	0.330	0.515	0.742	1.01	1.34
	Heater	Rev. per min.	1412	1216	1050	848	712	[illegible]	
		Hp.	0.735	1.00	1.31	2.04	2.94	[illegible]	

FANS AND BLOWE[…]

80. To procure fresh air and to ke[…] a problem of particular interest to tho[…] to be either temporarily or permanen[…] mer, especially, and in inland and lo[…] try, arrangements for good ventilati[…] business necessity to render a stor[…] habitable during the hot months, […] an equally important matter where […] congregate, as in audience room[…] etc.

81. For such **ventilation** it is n[…] in pure air, but to remove the vi[…] this process indefinitely. For […] however, the desired object is […] rooms in which lumber, cloth, […] ticles of merchandise are being […] ious gases or fumes which atte[…] facture, or to cause a circulati[…] pipe coils for maintaining equ[…] rooms or apartments. Tho[…] easy matter to accomplish, which will readily produce t[…]

82. A ventilating fan of […] in a circular aperture in t[…] desired — either to draw i[…] exhaust fan should be pl[…] in the same direction a[…] avoid having to contend […] and **location of air inlets** […] air currents should also b[…] ing the place for the fan[…] to be ventilated should […] should be at the opposite […] fan. The size of the fan […] largely upon local con[…] 18-inch **size** will be foun[…] 25 or 30 persons. Th[…] *cubic feet of air per hou*[…]

[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]	5.75	
[illegible]	14120	10240	2[…]
[illegible]	545	470	
[illegible]	1.34	1.83	
[illegible]	800	755	
[illegible]	5.15	7.05	
10800	15520	21130	2[…]
720	600	515	
1.18	1.70	2.31	
1163	971	830	
4.70	6.80	9.25	

INCHES

84	96	108	1[…]
23000	30156	38160	4[…]
70	62	55	
0.345	0.450	0.573	[…]
113	100	89	
1.15	1.51	1.91	
26950	35016	44500	5[…]
82	72	62	
0.548	0.740	0.905	
132	116	100	
1.54	2.10	2.52	
30400	40150	50900	6[…]
[illegible]	83	73	
0.700	1.00	1.27	
[illegible]	134	118	
[illegible]	3.20	3.83	

POWER OF DISK VENTILATING

				Inches				
				72	84	96	108	120
				25443	34642	45234	57250	70650
				123	106	93	82	74
				0.762	1.04	1.35	1.72	2.12
				109	173	150	132	119
				2.29	3.12	4.07	5.15	6.36
			[illegible]	28270	38480	50265	63600	78540
		[illegible]	166	136	120	103	91	82
		[illegible]	0.647	0.933	1.27	1.66	2.09	2.56
		293	268	220	194	167	147	132
		1.83	2.26	3.26	4.44	5.77	7.33	90.5
		19100	23566	33900	46176	60312	76300	94240
	min.	218	196	164	140	124	110	99
		0.910	1.13	1.62	2.20	2.87	3.63	4.48
	r min.	351	322	264	234	200	176	160
	Hp.	2.70	3.37	4.85	6.60	8.63	10.8	13.3
	Cu. ft. p. min.	22270	27500	39600	53900	70300	88950	109500
	Rev. per min.	254	230	190	164	144	128	115
	Hp.	1.19	1.55	2.12	2.89	3.77	4.77	5.89
	Rev. per min.	410	376	308	274	234	205	184
	Hp.	4.38	5.40	7.88	10.6	13.8	17.5	21.6
	Cu. ft. p.min.	25400	31400	45200	61500	80000	101200	125200
e	Rev. per min.	298	264	220	188	165	146	131
	Hp.	1.67	2.06	2.97	4.05	5.28	6.68	8.25
ter	Rev. per min.	468	429	352	314	268	234	210
	Hp.	6.62	8.17	11.8	16.0	20.9	26.5	32.7
	Cu. ft. p. min.	28600	35200	51000	69000	90200	114000	141000
e	Rev. per min.	330	294	245	210	185	163	148
	Hp.	2.22	2.75	3.97	5.39	7.04	8.90	11.0
ter	Rev .per min.	526	483	396	354	302	263	236
	Hp.	9.50	11.7	16.9	23.0	30.0	38.0	47.0
	Cu. ft. p. min.	31800	39260	56510	76960	100520	127200	157100
e	Rev. per min.	363	327	272	234	206	182	164
	Hp.	3.02	3.73	5.38	7.31	9.55	12.1	14.9
ter	Rev. per min.	585	528	440	380	336	292	262
	Hp.	11.7	14.5	20.8	38.3	37.0	46.8	57.8
	Cu. ft. p. min.	35000	43200	62200	84700	110500	139800	172500
e	Rev. per min.	400	360	300	257	228	202	175
	Hp.	3.82	4.72	6.79	9.25	12.1	15.3	18.8
ter	Rev. per min.	645	582	485	415	368	323	284
	Hp.	15.3	18.8	27.0	37.0	48.2	61.0	82.0

84. Data on Steel Plate Cast Iron and High-pressure Exhaust Fans[1]

(Type E, American Blower Co.)

No. of Fan	Dia. of Wheel	Width Periphery	Dia. Inlet Inside	½-oz. Pressure			¾-oz. Pressure			1-oz. Pressure		
				R.p.m.	Cu. ft. per min.	Brake hp.	R.p.m.	Cu. ft. per min.	Brake hp.	R.p.m.	Cu. ft. per min.	Brake hp.
30	19	7.125	12	830	1580	0.43	1012	1940	0.80	1170	2240	1.22
35	22	8.125	14	715	2155	0.59	876	2635	1.08	1010	3040	1.66
40	25	9.375	16	630	2820	0.77	772	3450	1.41	890	3980	2.17
45	28	10.875	18	563	3560	0.97	689	4360	1.78	795	5030	2.74
50	31	12.375	20	508	4400	1.20	622	5390	2.20	719	6220	3.39
55	34	13.5	22	464	5330	1.45	567	6525	2.66	655	7530	4.10
60	38	14.5	24	415	6350	1.73	509	7775	3.18	587	8960	4.89
70	42	15.125	27	375	7440	2.02	459	9120	3.72	530	10500	5.72
80	48	16.5	29	328	10050	2.75	402	12100	4.94	464	13980	7.62

84. (*Concluded*)

No. of Fan	1½-oz. Pressure			2-oz. Pressure			3-oz. Pressure			4-oz. Pressure		
	R.p.m.	Cu. ft. per min.	Brake hp.	R.p.m.	Cu. ft. per min.	Brake hp.	R.p.m.	Cu. ft. per min.	Brake hp.	R.p.m.	Cu. ft. per min.	Brake hp.
30	1436	2750	2.25	1655	3175	3.46	2035	3875	6.32	2345	4475	9.77
35	1240	3730	3.06	1430	4310	4.70	1755	5260	8.60	2025	6085	13.26
40	1090	4880	4.00	1260	5640	6.15	1545	6885	11.22	1785	7955	17.35
45	976	6180	5.06	1125	7140	7.79	1380	8710	14.36	1590	10050	21.90
50	882	7640	6.25	1015	8820	9.63	1247	10740	17.50	1440	12420	27.10
55	805	9250	7.58	927	10650	11.60	1138	13000	21.20	1310	15050	32.80
60	720	11000	9.20	830	12700	13.85	1020	15500	25.25	1175	17900	39.04
70	650	12900	10.57	750	14875	16.20	920	18150	29.60	1060	21000	45.80
80	569	17170	14.05	656	19800	21.60	805	24200	39.50	930	28000	61.00

[1] These fans are applicable to the removal of shavings, sawdust, heavy vapors, acid fumes, or steam from building or cooking vats, ventilating public toilet rooms, etc.

85. Data on High-pressure Exhaust Fans[1]
(Type P, American Blower Co.)

No. of Fan	Dia. of Wheel	Width of Periphery	Blast Area Sq. Ft.	Dia. Outlet Inside	Area of Outlet Sq. Ft.	Cir. of Wheel in Ft.		Pressure in Ounces 2	3	4	5	6
3	19.5	1.875	0.1033	7.25	0.2866	5.10	r.p.m.	1580	1936	2235	2510	2735
							cu. ft.	926	1135	1310	1460	1600
							hp.	1.015	1.86	2.88	4.0	5.25
4	22	2.125	0.132	8	0.349	5.76	r.p.m.	1400	1750	1980	2215	2420
							cu. ft.	1128	1380	1590	1780	1945
							hp.	1.23	2.26	3.47	4.86	6.38
5	24.5	2.375	0.164	9	0.442	6.40	r.p.m.	1260	1545	1780	1990	2180
							cu. ft.	1428	1715	2020	2255	2465
							hp.	1.56	2.87	4.40	5.88	8.10
6	27	2.875	0.219	10	0.546	7.06	r.p.m.	1140	1400	1615	1800	1975
							cu. ft.	1765	2160	2405	2790	3050
							hp.	1.93	3.54	5.44	7.62	10.00
7	32	3.375	0.305	11.75	0.754	8.39	r.p.m.	963	1180	1360	1520	1660
							cu. ft.	2435	2985	3440	3850	4200
							hp.	2.66	4.89	7.50	10.5	13.80

85. (*Concluded*)

No. of Fan		Pressure in Ounces 7	8	9	10	11	12	13	14	15	16
3	r.p.m.	2960	3160	3355	3540						
	cu. ft.	1735	1845	1960	2070						
	hp.	6.63	8.05	9.62	11.3						
4	r.p.m.	2620	2800	2970	3130	3280	3430	3535			
	cu. ft.	2110	2250	2385	2520	2640	2760	2840			
	hp.	8.06	9.85	12.2	13.8	15.8	18.0	20.2			
5	r.p.m.	2360	2520	2670	2820	2950	3080	3175	3335	3450	3570
	cu. ft.	2670	2845	3020	3195	3340	3500	3600	3770	3900	4030
	hp.	10.20	12.40	14.80	16.9	20.0	22.85	25.6	28.8	32.	35.3
6	r.p.m.	2140	2280	2420	2555	2675	2795	2880	3025	3130	3240
	cu. ft.	3310	3520	3740	3950	4130	4320	4450	4670	4830	4990
	hp.	12.66	15.35	18.35	21.6	24.8	28.25	31.6	35.6	39.7	43.6
7	r.p.m.	1800	1920	2035	2150	2250	2350	2420	2540	2625	2720
	cu. ft.	4560	4850	5150	5450	5700	5950	6140	6440	6660	6880
	hp.	17.45	19.90	25.25	29.8	34.2	38.9	43.6	49.2	54.6	60.25

[1] The pressure blower is useful wherever the requirements demand the delivery of air at high pressure, as in the case of cupola work.

86. Data on Volume Blowers[1]

(Type V, American Blower Co.)

No. of Fan	Dia. of Wheel	Width Periphery	Dia. Inlet Inside	½-oz. Pressure			¾-oz. Pressure			1-oz. Pressure		
				R.p.m.	Cu. ft. per min.	Brake hp.	R.p.m.	Cu. ft. per min.	Brake hp.	R.p.m.	Cu. ft. per min.	Brake hp.
1	8.5	2	4.75	1850	223	0.06	2270	273	0.11	2620	315	0.17
2	10.25	2.75	5.5	1535	332	0.09	1880	407	0.17	2170	469	0.26
3	12	3.25	6.5	1310	464	0.13	1600	569	0.23	1850	656	0.36
4	15.5	4.375	8.5	1015	795	0.22	1240	975	0.40	1435	1122	0.61
5	19	5.5	10.5	830	1185	0.32	1013	1450	0.59	1170	1675	0.92
6	22.5	6.5	12.5	700	1685	0.46	858	2065	0.84	990	2385	1.30
7	26	7.5	14.5	606	2235	0.61	742	2740	1.12	858	3160	1.72
8	29.5	8.5	16.5	534	2910	0.79	654	3560	1.45	755	4110	2.24
9	33	9.5	18.5	477	3660	1	585	4490	1.83	675	5175	2.82

86. (*Concluded*)

No. of Fan	1½-oz. Pressure			2-oz. Pressure			3-oz. Pressure			4-oz. Pressure		
	R.p.m.	Cu. ft. per min.	Brake hp.	R.p.m.	Cu. ft. per min.	Brake hp.	R.p.m.	Cu. ft. per min.	Brake hp.	R.p.m.	Cu. ft. per min.	Brake hp.
1	3210	386	0.32	3710	446	0.40	4550	545	0.89	5250	630	1.37
2	2660	576	0.48	3070	649	0.71	3770	812	1.33	4350	940	2.05
3	2275	805	0.66	2620	930	1.02	3220	1132	1.85	3720	1310	2.86
4	1760	1377	1.13	2030	1500	1.74	2405	1940	3.16	2875	2245	4.00
5	1435	2055	1.68	1655	2375	2.59	2033	2900	4.73	2345	3350	7.31
6	1215	2030	2.40	1400	3380	3.60	1716	4125	6.74	1980	4775	10.40
7	1050	3880	3.18	1210	4475	4.88	1485	5460	8.02	1715	6310	13.75
8	928	5040	4.13	1065	5820	6.35	1310	7110	11.60	1510	8215	17.00
9	825	6350	5.20	956	7340	8	1170	8960	14.60	1350	10350	22.60

[1] Volume blowers are used where a large volume of air at moderate pressure is desired, as in the case of forges, furnaces, and steam boiler forced draft.

87. Motor Rating required for Volume Blowers given in Table **86**

1½-oz. Pressure		2-oz. Pressure		3-oz. Pressure	
No. of Fan	Motor Rating Hp.	No. of Fan	Motor Rating Hp.	No. of Fan	Motor Rating Hp.
3	0.75	3	1.10	3	2.00
4	1.25	4	2.00	4	3.50
5	2.00	5	3.00	5	5.25
6	2.75	6	4.00	6	7.50
7	3.50	7	5.50	7	10.00
8	4.50	8	7.00	8	12.75
9	5.75	9	9.00	9	16.00

88. Power required to drive Air Compressors

Diameter Cylinders	Stroke In.	Rev. per Min.	Piston Speed Ft. per Min.	Capacity Cu. Ft. Free Air per Min.	Air Pressure designed for	Horsepower necessary to operate Compressor
6[1]	6	150	150	29	45 to 100	3.5 to 5.5
8	6	150	150	51	20 to 45	3.5 to 6
10	6	150	150	81	15 to 20	4 to 5.5
8[1]	8	150	200	69	50 to 100	9 to 13
10	8	150	200	108	30 to 50	10 to 13.5
12	8	150	200	156	20 to 30	10 to 14
10[1]	10	150	250	134	55 to 100	18 to 26
12	10	150	250	194	35 to 55	19 to 26
14½	10	150	250	266	25 to 35	21 to 26
16½	10	150	250	348	15 to 25	18 to 27
12½[1]	12	150	300	236	60 to 100	34 to 45
14½	12	150	300	317	40 to 60	35 to 45
16½	12	150	300	414	30 to 40	37 to 45
18½	12	150	300	526	15 to 30	28 to 47

[1] These compressors have piston inlet valves.

89. Table **83** gives the cubic feet of air per minute which can be handled by fans of various sizes running at certain speeds and requiring a given horsepower, both for operation *in free air and in* connection with a heater. For example, a

42-inch fan working with a free and unobstructed discharge will deliver 11,541 cu. ft. of air per minute, producing a velocity of 1200 ft. per minute, when running 280 revolutions per minute, and will require 0.55 hp. for operation. When attached to a heater composed of coils with proper free area in order to deliver the same amount of air at the same velocity, the fan will have to run 453 revolutions per minute, requiring 1.64 hp. for operation.

90. It will be observed that in doubling the speed of the fans referred to in Table **83**, the air capacity of the same fan is doubled or approximately so, and that the horsepower required is more than proportional to the increase.

AUTOMOBILE CHARGING

91. This is a load that can be worked in very nicely at convenient times, when the load on the power lines is low. By arranging for **off-peak service** special rates to automobile charging stations may be made.

92. For city work the **electric automobile** is becoming more and more popular. It is especially suited for trucking and delivery service where vehicles are continually circulating from a central point. The control is so simple that any untrained man can operate it. The cost of maintenance is low and regular, and in point of reliability it is superior to the gasolene engine, especially when unskilled drivers are in charge. The **life of a battery** is from 8000 to 12,000 miles.

93. Until comparatively recently it has been the practice to use a motor generator set in charging automobile batteries from an alternating current service. During the past few years, however, the **mercury vapor arc rectifier** has come rapidly into favor because of the simplicity of its operation, and also because of its economy, the alternating current being transformed thereby into direct current with about one half the loss of the motor generator outfit. The rectifiers come in four standard sizes of 10, 20, 30, and 40 amperes, and are furnished for 110, 220, and 330 volts alternating current. The rectifier is designed for use on 60-cycle alternating current, but will operate satisfactorily from 25 to 140 cycles, the direct-current maximum voltage being 15

per cent higher when operated at 25 cycles, and 15 per cent lower when operated at 140 cycles, than at 60 cycles.

94. The direct current furnished by the rectifier will have about 50 per cent of the voltage of the alternating-current service circuit; in other words, a 220-volt alternating-current service circuit will give about 115 volts in direct current at full load, but this may be cut down, by varying the rheostat and the reactance, to about 45 volts. The **efficiency of the rectifier** is over 75 per cent from quarter to full load with 80 volts direct current, and runs from 80 per cent to 85 per cent from quarter to full load at 112 volts direct current.

ELEVATORS

95. The **electric elevator** is coming more into use for passenger and freight service. It is in every way superior to the old mechanical drive, and its cost and operating expense are less than the corresponding cost for hydraulic installations, this being especially true in small plants. The electric machine is more efficient, takes less space, is less complicated, and requires less attendance than the hydraulic type.

96. The electric elevator is easily equipped with **safety devices** such as automatic stops, which operate when all doors are not closed or when the car passes a given point. The **push-button elevator** requires no regular operator. The passenger operates the car by pushing a button corresponding to the floor desired; the car goes to that floor and stops of its own accord, and when the door is closed, it proceeds to answer the next push-button call, stopping automatically at the floor from which the call originated.

97. Tables **98** to **102** show the **energy consumption** and **cost of operation** for **various classes of elevator service.** The average hydraulic elevator consumes about 6 kw.-hr. per car mile, while the straight electric consumes only about 3.5 kw.-hr. per car mile.

Comparison of average monthly consumption of energy per horsepower in the case of the motor-driven elevators in Tables **98** to **102**.

The cost of the elevator service as given in the tables is based on the rates made by one of the larger central stations, *but rates, of course, vary.*

98. Small Belt-connected Freight Elevators used for Infrequent Service

Hp. of Motor	Average Kw.-hr. per Month	Average Kw.-hr. per Hp. per Month	Average Monthly Bill
15	130.3	8.68	$13.03
15	115.1	7.67	11.51
12	405.2	33.8	30.26
10	44.0	4.4	4.40
10	20.6	2.06	2.06
10	94.3	9.43	9.43
10	38.6	3.86	3.86
10	125.7	12.57	12.57
10	106.3	10.63	10.63
10	97.3	9.73	9.73
10	51.2	5.12	5.12
10	62.5	6.25	6.25
10	66.13	6.61	6.61
9	31.6	3.51	3.16
7.5	14.8	1.98	1.48
7.5	33.2	4.43	3.32
7.5	37.2	4.96	3.72
7.5	10.4	1.39	1.04
7.5	29.1	3.88	2.91
7.5	52.3	7.0	5.23
7.5	7.75	1.03	0.78
7.5	144.0	19.2	14.40
7.5	60.2	8.03	6.02
7.5	60.6	8.08	6.06
7.5	10.31	1.37	1.03
7.5	60.61	8.08	6.06
7.5	32.9	4.38	3.29
7	44.9	6.41	4.49
7	32.6	4.66	3.26
7	91.3	13.0	8.69
5	49.4	9.9	4.94
5	7.8	1.56	0.78
5	49.8	9.96	4.98
5	91.5	18.3	9.15
5	30.8	6.16	3.08
8.41 Av.	97.44 Av.	8.01 Av.	$6.38 Av.

99. Direct-connected Freight Elevators

Hp. of Motor	Average Kw.-hr. per Month	Average Kw.-hr. per Hp. per Month	Average Monthly Bill
7.5	40.1	5.34	$ 4.01
10	49.6	4.96	4.96
10	192.6	19.26	19.26
12	707.4	58.9	45.70
12	282.3	23.6	22.83
12	102.3	8.5	10.23
12	294.1	24.5	23.59
15	80.6	5.37	8.06
15	68.6	4.57	6.86
17.5	114.7	6.56	11.47
12.3 Av.	193.2 Av.	15.71 Av.	$15.69 Av.

100. Direct-connected Passenger Elevators

Hp. of Motor	Average Kw.-hr. per Month	Average Kw.-hr. per Hp. per Month	Average Monthly Bill
1 — 7	203.1	29.	$18.18
1 — 7.5	771.4	102.8	48.57
1 — 7.5	177.5	23.7	16.77
1 — 10	509.2	50.9	35.41
1 — 10	259.7	25.97	21.17
1 — 10	153.4	15.3	15.61
1 — 10	82.0	8.2	8.20
2 — 12	1694.3	70.6	83.16
1 — 12	786.9	65.6	49.45
1 — 13	738.1	56.8	46.91
1 — 15	527.0	35.1	36.35
1 — 15	345.4	23.03	37.27
2 — 15	1450.7	48.3	75.15
1 — 15	685.7	45.7	44.29
1 — 16	682.9	42.7	44.15
1 — 22	1122.5	51.1	62.90
12.32 Av.	638.5 Av.	43.6 Av.	$33.87 Av.

101. Hydraulic Passenger Elevators

Hp. of Motor	Av. Kw-hr. per Month	Av. Kw-hr. per Hp. per Month	Av. Monthly Bill
10	476.9	47.69	$ 33.73
10	861.1	86.11	52.44
10	361.1	36.0	28.15
10	754.4	75.4	47.38
15	1880.5	125.4	87.31
15	499.0	33.27	34.95
20	2198.0	109.45	101.64
30	2962.5	98.75	133.56
15 Av.	1248.1 Av.	83.20 Av.	$ 64.89 Av.

102. Energy Consumption of Elevator Motors.

Building	Number	Elev. Max. Load in Lb.	Trips per Hour	Trips per Month	Length of Trip	Car Miles per Month	Total Car Miles per Month	Kw-hr. per Month	Kw-hr.[1] per Car Mile
Office	1	2000 P.	36	9288	154′ 3″	271.3	553.2	1215.0	2.19
	1	2000 P.	36	9288	160′ 3″	281.9			
Office	4	3200 P.	22	5720	314′ 4″	340.5	1601.2	5522.0	3.45
	1	3200 P.	22	3432	365′ 0″	239.2			
Office	4	2600 P.	34	7825	322′ 0″	477.2	1908.8	5525.0	2.89
Office	3	2500 P.	30	7800	318′ 0″	469.7	1409.1	3976.7	2.82
Office	1	3100 P.	30	9360	243′ 4″	431.3	902.8	2909.4	3.22
	1	3100 P.	30	9360	266′ 0″	471.5			
Mail Order	2	3000 P.	30	7800	280′ 0″	411.7	1774.0	5012.6	2.82
	2	5300 F.	15	4290	280′ 0″	227.5			
	2	3000 F.	15	4290	280′ 0″	227.5			
	1	3000 F.	15	4290	50′ 0″	40.6			
Wholesale Hardware	2	2750 P.	40	10400	260′ 0″	512.1	2600.2	7308.3	2.81
	3	3600 F.	14	4004	260′ 0″	197.0			
	1	2500 F.	14	4004	260′ 0″	197.0			
	4	6000 F.	14	4004	260′ 0″	197.0			

Note. — Tests of 33 of the large-sized passenger and freight elevators of the drum type, the data being taken from buildings in which the elevators have very heavy work, and where they are operated mainly on a regular time schedule.

[1] These figures are very low. Average New York practice is nearer 3.5 *to 4.0 kw-hr. per* car mile.

CE-MAKING AND REFRIGERATING MACHINES

)3. Refrigerating machines in large part make use of **ıonia** in the production of low temperatures. The ıonia is drawn into a compression chamber, and com-sed to a pressure of approximately 150 lb. per square inch. compressed gas then passes into a condensing chamber aining series of pipes or coils over which cold water s. Under the combined influence of the pressure pro-:d by the compressor and the cooling influence of the :r, the gas becomes liquefied. The liquid ammonia then es into a receiver, where it is stored. From this receiver, n the machine is in operation, the liquid ammonia passes ıe expansion coils, and there expands to a gaseous form, rbing large quantities of heat, and performing the actual : of refrigeration. The amount of heat so absorbed or n up is equal to the amount that was previously given o the water during the condensation of the ammonia ı a gaseous to a liquid form.

Capacities of Ice Machines, and Horsepower required to operate Them

Refrigerating acity in Tons per 24 Hours	Ice-making Capacity in Tons per 24 Hours	Horsepower Required
0.5	0.25	1
1	0.5	2
2	1	4
3	1.5	6
5	2.5	9
8	4	13
10	5	15
12	6	17
16	8	22
20	10	26
25	12.5	32
30	15	37.5
35	17.5	43
40	20	48
50	25	60

105. Another form of machine frequently used, and in more favor with some people, is the **carbonic anhydride machine** using carbon dioxide (CO_2). This machine has two special advantages at least: the absence of the smell of ammonia, and the fact that in case of fire in the refrigerating room, a safety valve opens at a slight increase of temperature, and fills the room with the gas, which drives out the oxygen and stops combustion without injury to the contents of the room.

106. The horsepower in Table **104** is based on condensing water (the water used for cooling) of a temperature of 70 deg. F. When condensing water of a higher temperature is used, the consumption of power will increase accordingly.

107. Ice machines are used not only to make ice, but also in **cold storage rooms**. In such cases it is customary to allow about 5000 cubic feet per ton of installed refrigeration capacity. The average heat of articles submitted to cold storage is 78. Allowing 50 per cent for radiation, a one-ton machine will take care of —

$$\frac{284000}{2} = 142000 \text{ B. t. u.}$$

Assuming the average temperature of the stock to be 78 deg. F., a one-ton machine will reduce to 32 deg. F.

$$\frac{142000}{(78-32) \times 0.78} = 4000 \text{ lb. per 24 hours.}$$

108. It was found in the experience of the large electric central station that for cooling water, **refrigerating** meats, and cooling candies the average **cost** per horsepower of motors connected was about \$3.50 per month — the average motor installation in the cases examined being 15 hp. and a maximum average charge of about \$4.50 per connected horsepower per month applying to the refrigeration of meats, and a minimum average charge of about \$1.25 per connected horsepower per month applying to the cooling of water.

109. Artificial refrigeration is not only the cheaper, but it is also a much cleaner and handier method in all respects, and its field of application is a broadening one. The artificial **manufacture of ice** is also a profitable undertaking, depending upon locality, quantities produced, and cost of natural ice.

LOAD FACTORS

110. Load factor is defined in several different ways, but its general significance is the same in all cases; namely, it is a measure of the ratio of the average consumption of an installation to the maximum. The average is usually taken to be the total energy in kilowatt-hours divided by the time of operation, while there are several ways of fixing the maximum. It may be taken as the sum of the full-load ratings of all apparatus connected to the lines; or, it may be taken as the actual maximum demand registered by a maximum-demand indicator; or, it may be determined by the maximum load sustained for a given time as shown by a recording wattmeter. In Table **114** shown herewith it is assumed as the ratio of the actual average load to the maximum, the operating time being taken as 350 hr. a month.

111. An examination of the list of average loads in Table **114** will reveal a considerable difference in favor of the **individual motor drive** over the **group drive**, as shown in the percentage of average load to full connected motor load, that is, load factor. This difference, however, does not indicate the exact difference in consumption of energy, since the rating of a group-drive motor installation is usually only about from 75 to 80 per cent of that of an individual motor drive. The latter, however, is certainly more economical in many, if not in most, instances; the saving usually effected being largely in excess of the interest and depreciation charges on the extra cost of installing the additional motors required. It should be noted that the average loads designated in Table **114** are based in nearly every instance on a number of cases, which cases naturally vary considerably among themselves. Therefore, in estimating the probable average load in any given case the solicitor must exercise good judgment, that kind of judgment which develops through acquaintance with factory conditions.

112. The **load factor** of an installation has an important **bearing on the cost of** supplying the **energy**. The central station must be equipped to supply at a moment's notice the maximum demand of the system, and the greater the *difference between this* maximum and the average load, the

greater will be the cost of producing a given amount of energy. The first cost of equipment is, of course, dependent upon the maximum demand, while the operating cost is greatly increased by fluctuating load. This is especially true with the steam-generating part of the plant where boilers must stand with banked fires waiting for heavy loads of short duration. If a customer's load comes on at any time when the station load is light, the company can well afford to make a considerable reduction in the rate as an inducement rather than operate at a low-load factor. When figuring the **probable monthly bill** of a given installation, multiply the maximum power by the load factor to get the average load, and then multiply the product by the hours of operation per month, which will give the total kilowatt-hours per month.

113. Power Loss in Line Shafting

Class of Work	Total Horsepower	Percentage of Total Power to drive Shafting	Horsepower absorbed per 100 Feet of Shafting
Wire drawing and polishing	400	39	14.0
Steel stamping and polishing	74	77	9.8
Boiler and machine work	38	65	4.77
Heavy machine work	112	57	5.7
Heavy machine work	168	54	8.55
Light machine work	40	51	2.75
Bridge-building machinery	59	81	3.28
Manufacture of small tools	74	54	8.0
Manufacture of small tools	47	52	2.5
Sewing machines and bicycles	190	57	4.36
Sewing machines	107	70	5.08
Screw machines and screws	241	47	6.33

4. Load Factors for Different Classes of Service

Service	Kind of Drive	Avg. Kw-Hr. per Month per Hp.	Load Factor[1] per Cent
mpressor for doctor's office	Indiv.	15.9	6.1
ies			
ad	Indiv.	51.0	19.5
ad	Group	65.0	25.1
cker	Group	130.0	50.0
l factory	Group	30.0	11.6
nanufacture	Group	56.0	21.6
ng machine	Group	104.2	40.7
washer	Indiv.	12.0	4.7
naker (paper)	Group	78.0	30.0
actory (wood)	Group	78.3	30.1
smith	Group	84.0	32.4
and shoes	Group	131.8	50.8
shop	Group	86.6	33.8
shop	Indiv.	45.2	17.4
finishing	Group	117.0	45.0
n manufacture	Group	60.3	23.2
eries	Group	176.8	68.0
manufacture	Group	20.5	13.8
ers and packers	Group	80.0	30.8
ers and packers	Indiv.	40.0	15.8
y manufacture	Group	96.0	37.2
y manufacture	Indiv.	30.6	18.8
t cleaning	Group	78.3	30.1
ge building	Group	73.0	28.1
ge building	Indiv.	33.8	13.0
nt-mixing machinery	Group	54.0	20.8
ical works	Indiv.	60.8	23.44
ing manufacture	Group	103.5	39.8

[1] ad factor here signifies the ratio of the actual energy used in kilowatt hours to ximum kilowatt hours which would be used were the motors to ru 350 hours per month.

114. Load Factors for Different Classes of Service (*Continued*)

Service	Kind of Drive	Avg. Kw-Hr. Per Month per Hp.	Load Factor per Cent
Coffee mills	Indiv.	39.5	15.2
Cotton mills	Group	162.2	62.4
Concrete mixer	Indiv.	78.0	30.0
Corrugating machine	Group	40.5	15.6
Dairy machine	Group	156.0	60.0
Dye works	Group	54.6	21.0
Electrotypers	Group	124.7	46.9
Electrotypers	Indiv.	58.8	22.5
Elevator builders	Group	64.8	24.9
Feather cleaning	Indiv.	67.0	25.7
Feather renovator	Group	61.0	23.5
Foundries	Indiv.	55.7	21.3
Foundries	Group	114.0	43.7
Furniture manufacture	Indiv.	81.9	31.5
Furniture manufacture	Group	93.0	35.6
Flour mills	Group	125.0	48.1
Gas engine builders	Group	51.0	19.6
Gas meter manufacture	Group	158.0	60.8
General manufacture	Group	96.0	37.0
General manufacture	Indiv.	41.0	15.8
Glass grinding	Group	95.5	36.6
Grain elevators	Group	85.0	32.6
Grain elevators	Indiv.	26.0	10.0
Grain and feed mill	Indiv.	40.0	15.5
Grinding and pulverizing stone	Indiv.	100.9	38.8
Harness shop	Indiv.	8.0	3.1
Hoist unloading vessels	Indiv.	9.6	3.7
Hoist and conveying	Group	56.0	21.5
Ice machines	Indiv.	127.0	49.0
Ice-cream makers	Indiv.	20.0	7.7
Ice-cream manufacture	Group	22.0	8.5

. Load Factors for Different Classes of Service
(*Continued*)

Service	Kind of Drive	Avg. Kw-Hr. per Month per Hp.	Load Factor per Cent
y manufacture	Group	82.5	31.6
iealer	Indiv.	21.8	8.4
ry	Group	88.7	34.0
ry	Indiv.	66.3	25.5
ıtory metal, testing	Indiv.	1.8	0.7
:r cutter (stamping)	Group	104.0	40.0
pe	Indiv.	99.6	38.3
ne shop	Indiv.	42.8	16.5
ne shop	Group	89.7	34.4
e finishing	Indiv.	53.0	20.4
e finishing	Group	98.8	38.0
:ss and bed manufacture	Group	208.0	80.0
ıaper	Indiv.	39.3	15.1
ıaper	Group	99.2	38.0
ıental iron works	Group	98.0	37.7
dealers	Indiv.	42.0	16.3
factories	Indiv.	46.0	17.7
manufacture	Group	65.0	25.0
n maker	Group	67.6	26.0
: manufacture	Indiv.	101.0	38.8
ıg, job	Indiv.	65.2	25.0
ıg, job	Group	76.5	29.4
ıg ink manufacture	Group	104.0	40.0
›ackers	Group	109.0	41.9
y	Group	8.8	3.4
(oil)	Indiv.	7.8	3.0
ıing and pipe fitting	Indiv.	18.2	7.0
ıing	Group	56.1	21.5
ad switch manufacture	Indiv.	8.8	3.4
eration, meat	Indiv.	109.5	42.1

114. Load Factors for Different Classes of Service *(Concluded)*

Service	Kind of Drive	Avg. Kw-Hr. per Month per Hp.	Load Factor per Cent
Refrigeration, bottler	Indiv.	122.7	47.2
Refrigeration, dairy	Indiv.	173.0	66.7
Rubber manufacture	Group and Indiv.	52.0	20.0
Rubber works	Indiv.	53.8	20.7
Sausage maker	Indiv.	38.2	14.7
Seed warehouses	Group	44.0	17.0
Sheet-metal works	Group	70.0	26.9
Shirt manufacture	Group	83.2	32.0
Soap manufacture	Group	64.0	24.6
Spice mill	Group	68.0	26.0
Spice mill	Indiv.	52.2	20.0
Steel casting	Indiv.	95.8	37.0
Structural steel manufacture	Indiv.	48.3	18.5
Stone cutting	Indiv.	81.0	31.1
Stone cutting	Group	100.0	38.5
Stone granite polishing	Indiv.	28.1	10.8
Structural steel	Group	81.0	31.1
Tannery	Group	117.0	44.9
Testing Laboratory	Indiv.	1.8	0.7
Tobacco	Group	76.0	29.1
Top-roll coverer	Group	130.0	50.1
Telephone company	Indiv.	104.0	40.0
Trunk manufacture	Group	5.2	2.0
Welding	Group	15.3	5.9
Wheel-tiring machine	Indiv.	9.6	3.7
Wheelwright	Indiv.	48.6	18.7
Wood-working	Indiv.	34.0	13.1
Wood-working	Group	59.8	23.0
Woolen mills	Group	140.0	54.0
Wall paper manufacture	Group	65.0	25.0
Wagon builders	Group	26.0	10.0

Horsepower required to drive Various Machines (Lloyd Assoc. Edison Ill. Cos., 1905)

Service	Required Hp.	Service	Required Hp.
		Bookbinding and Printing — Cont.	
xers	1 to 5		
flour mixer	10	Type-casting machine	0.5
-cracker baker	1 to 3	Paper basting machine	2
		Knife grinder	2
ng and Printing		44-in. Oswego cutter	2
ess (pony)	1	36-in. Oswego cutter	1
). o press	2.5	48-in. Sanborn cutter	2
). oo press	3	24-in. Sheridan cutter	0.25
). ooo press	4	Seybold embosser	5
). oooo press	5	Cardboard splitting ma-	
25 by 38 press	2	chine	1
by 30 press	1.5	Envelope machine	1
3 by 52 press	3	Seybold 3-knife book	
by 56 press	5	cutter	5
by 60 press	5	Victory embossing ma-	
by 60 press	5	chine	1
erfecting press		Ink mills	1 to 7.5
4	7.5	Blackhall embossing ma-	
Whitlock press	2	chines	0.5
Campbell press	4	Monotype machine and	
ipbell press	2	air pump	2
entury press	4	Colts Armory presses 12	
entury press	1.5	by 19	1
scott press	1.5	Colts Armory presses 10	
ng machine	1	by 12	0.5
mer	3	10 by 12 Gordon job	
sher	3	press	0.25
ng machine	1.5	12 by 18 Gordon job	
ossing machine	3 to 10	press	0.5
her	0.25	12 by 18 Golding press	0.75
hing machine	0.25	36 by 49 folding machine	1
ng machine	0.125	40 by 56 folding machine	2
tter	1	48-in. Brown folder	2
achine	1	Case roller	0.25
machine	0.25	Envelope folder	0.66
mp	2 to 5	Glue mixers	1
achine	0.25	48-inch Envelope die press	1
ornering ma-		8-page newspaper press	8
	0.5	16-page newspaper press	16
ming machine	0.125	18-page newspaper press	18
rfecting press,		24-page newspaper press	24
3	1	28-page newspaper press	28
Cranston press	1.5		
ampbell press	1.5	*Breweries*	
entury press	7.5	Large centrifugal grain	
entury press	4	pump	40
ary press	2	Pasteurizer	3
er press	2.5	Labeling machine	5
er press	5	Hop machine	3 to 12
er press	7.5	Pitching machine	3.5
cylinder press		Carbonater	2 to 5
	1	Racking pump	2
scott press	5	Bran bag hoist	5
scott press	5	Grooming machine	3
scott press	2	Clipper	1
achine	0.25	Barrel washer	2

115. HORSEPOWER REQUIRED TO DRIVE VARIOUS MACHINES
(*Continued*)
(Lloyd Assoc. Edison Ill. Cos., 1905)

Service	Required Hp.
Breweries — Cont.	
Malt mill	15
Rice mash	20
Mash tubs	25
Butchers	
Large meat chopper, o knife	15
Lard cooler	3
Small enterprise meat grinders	1 to 3
No. 00 enterprise meat grinder	10
No. 3 boss mixer	7.5
Spice mill	2
Knife meat rocker	2
Lard press	5
[illegible] *Machines*	
Marshmallow kettle	1
[illegible]	1
[illegible] cleaning machine	0.5
[illegible] kettle	1
[illegible] mixer	1
[illegible]	0.25
[illegible]	0.5
[illegible]	0.25
[illegible]	0.5
[illegible] roaster	3
[illegible]	0.5
[illegible]	3
[illegible]	2
[illegible]	1
[illegible] breaker	2
[illegible]	0.5 to 5
[illegible]	1.5
[illegible]	1
[illegible]	3
[illegible]	15
[illegible]	5
[illegible]	0.75
[illegible]	0.5
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]

Service	Required Hp.
Candy Machines — Cont.	
Chocolate shaking table	0.5
Chocolate mixing kettle	1
Chocolate rolling machine	5
Walters chocolate mixer	0.5
Walters chocolate dipping machine	0.5
Holmes chocolate coating machine	0.5
Coopers Shops	
Large hooping machine	5
Stave planer	4
Crushing machine	5
Heading machine	2
Barrel planer	2
Stave bending machine	1
Cotton Machinery	
Braher cotton picker	10
Cotton carding machine	20
Small cotton carding machine	2
Finisher picker	15
Cotton washer	7.5
Cotton tumbling barrel	2
Cotton dryer	20
Electrotyping and Stereotyping Machines	
Boyle router	1
Wesel Daniel planer	2
Roughers	2
Combined drill and jig saw	0.5
Trimmer	0.5
Saw	0.5
Small planer	0.5
Agitator	0.5
Reveler and grinder	1
Zinc etching rocker	1
Black leader	0.5
Molding press	4
Plate reducer	2
Bender	3
Flat shaver	3
Wax shaver	0.5
Etching machine	3
Etching tubs	0.5
Autoplate machines	10
Scorcher	0.5
Trimmer	3
Double-page shaver	3
Double-page tail cutter	5
Matrix roller	2

. HORSEPOWER REQUIRED TO DRIVE VARIOUS MACHINES
(*Continued*)
(Lloyd Assoc. Edison Ill. Cos., 1905)

SERVICE	REQUIRED HP.	SERVICE	REQUIRED HP.
Machines		*Jewelers*	
or	1 to 7.5	Polishing lathe	2
single	10	Polishing stone	1
double	20	Jewelers' lathe	0.166 to 2
pickers	1 to 3		
tufters	2	*Laundry Machinery*	
icker	1 to 5	Cylinder washers	2 to 5
		Wringer	1 to 3
s		Starcher	0.5 to 2
rattlers	1 to 10	Dampener	0.25 to 0.5
grinders	3 to 5	Mangles	3 to 10
wers, No. ¼	5	Ironer	1 to 3
wers, No. ½	6	Extractors	3 to 5
wers, No. 1, cu- .5 tons per hour	7	*Macaroni Machines*	
wers, No. 2, cu- .5 tons per hour	10	Macaroni dough mixer	2
		Macaroni screw press	2
wers, No. 3, cu- 3.5 tons per	15	Macaroni cut off	0.25
		Leather Manufacture	
wers, No. 4, cu- .5 tons per hour	20	Fleshing machine	30
		Wash mill	10
wers, No. 5, cu- tons per hour	35	Shaving or skinning machine	10
wers, No. 5, cu- 3 tons per hour	45	Dry mill	5
		Reels	2 to 5
wers, No. 7, cu- 8 tons per hour	60	Staking machine	5
		Splitting machine	10
wers, No. 8, cu- 4 tons per hour	80	*Machine Shops*	
wers, No. 9, cu- 5 tons per hour	100	22-in. to 24-in. engine lathe	2
Machinery		26-in. to 30-in. engine lathe	2.5
inders	0.5 to 3	36-in. to 42-in. engine lathe	3.5
asters	2		
olishers	2	48-in. to 54-in. engine lathe	5
gar pulverizer	15		
owder mixer	1	60-in. engine lathe	6
rinder	2	72-in. engine lathe	6
xer	3 to 10	84-in. engine lathe	10
lls	3 to 15	Forge lathes, 50 per cent larger motors than above	
offee mixer, 30-	25		
cker	20	26-in. planer, single-head	5
achine	0.5	30-in. to 36-in. planer, double-head	9
her	1		
Machinery		38-in. to 40-in. planer, double-head	12
freezer	1	44-in. to 48-in. planer, double-head	14
freezer	2		
freezer	3	54-in. planer, double-head	15
freezer	5		
ier	1	60-in. planer, double-head	18
eam separator	5		
asher	1	72-in. planer, double-head	22

115. HORSEPOWER REQUIRED TO DRIVE VARIOUS MACHINES
(*Continued*)
(Lloyd Assoc. Edison Ill. Cos., 1905)

Service	Required Hp.
Machine Shops — Cont.	
84-in. planer, double-head	25
76-in. planer, double-head	30
120-in. planer, double-head	40
144-in. planer, double-head	50
36-in. swing boring mill	4
51-in. swing boring mill	5
60-in. swing boring mill	6.5
72-in. swing boring mill	7.5
84-in. swing boring mill	10
120-in. swing boring mill	12
192-in. swing boring mill	15
16-in. stroke shaper	3
18-in. stroke shaper	3.5
24-in. stroke shaper	5
30-in. stroke shaper	6
10-in. stroke crank slotter	4
14-in. stroke crank slotter	5
18-in. stroke crank slotter	6
30-in. stroke crank slotter	7.5
24-in. forge slotter	10
40-in. forge slotter	13
60-in. forge slotter	15
66-in. drive wheel lathes	10
90-in. drive wheel lathes	15
26-in. slab milling machine	8
36-in. slab milling machine	12
48-in. slab milling machine	15
48-in. horizontal boring machine	2.5
66-in. horizontal boring machine	4
72-in. horizontal boring machine	5 to 7.5
24-in. drill press	1.5
40-in. drill press	3
60-in. drill press, heavy	5
Small radial drill	2
Medium radial drill	3
Large radial drill	5
Automatic screw machine	1
Fox lathes	1 to 3
Turret lathes	1 to 3
1-in. pipe cutter	0.5
2-in. pipe cutter	1
4-in. pipe cutter	2
8-in. pipe cutter	3
12-in. pipe cutter	5
24-in. pipe cutter	10
Machine Shops — Cont.	
Key seating machine	2
Cut off saw	0.25
Speed lathes	0.5
Tool lathes	1
Large 12-spindle drill	10
Double buffing and polishing machines	3 to 10
12-in. buffer	2
16-in. buffer	5
24-in. buffer	10
Bolt cutter	1 to 3
Rod straightening machine	5
6-in. emery wheels	0.5 to 1
12-in. emery wheels	3 to 7.5
18-in. emery wheels	5 to 10
Steel shears, ¼-in. steel	1 to 3
Steel shears, ½-in. steel	7
Steel shears, ¾-in. steel	7.5
Hons' beam cutter	10
Punch, ¼-in. hole in ½-in. steel	1
Punch, 0.5-in. hole in ½-in. steel	3
Punch, ¾-in. hole in ¾-in. steel	5
Punch, 1-in. hole in 1-in. steel	7.5
Miscellaneous	
Chemical grinding machine	15
Rope hanker	1.5
2-in. pipe drawing machine	10
Borax crushers	35
Borax conveyor	15
Rib knitting machine	0.166
Round knitting machine	0.166
Stamp canceling machine	1 to 2
Horse groomer	2 to 3
Churn	0.5 to 2
Addressograph	0.5
Cloth cutter	0.125 to 0.25
Carpet cleaner	5 to 10
Dishwasher	0.5 to 5
Weaving machines	1 to 5
Carpet sewing machine	0.25
Ordinary sewing machine	0.125
Ink mill	2 to 7.5
Paint Machines	
Paint grinders	3 to 15
Screen and conveyor	5

5. Horsepower required to drive Various Machines (*Continued*)

(Lloyd Assoc. Edison Ill. Cos., 1905)

Service	Required Hp.
Machines — Cont.	
mill for lead grind-	35
l for lead grinding	20
and mixer	3
:leaner	10
	7.5
ıulverizer	2 to 10
; tanks	3
oll	10
: machine	5
mineral paint ıer	20
Box Machines	
; machine	1
:cutter	0.125
board slitter	1
g machine	0.25
·ing machine	0.1
stayer	0.125
ng machine	0.5
; machine	0.5
titcher	0.125
›ing machines	0.125
ing machines	0.333
ess	0.666
·oller	0.25
ing machine	0.25
box machine	1
ng machine	0.25
press	5
ne mixer	2
ınd dyer	2
rating Machines	
	2
	3.5
	5
	6
	7.5
	9
	10
	12
	13.5
	15
	25
Grinder	
rubber grinder	20
r calendar	7.5
r washer	12
'leaning Machinery	
seed threshing ma- e	20

Service	Required Hp.
Seed Cleaning Machinery — Cont.	
Seed cleaning mill	1
Seed reel	5
Large monitor seed mill	10
Bag filler	2
Blower cleaner	10 to 20
Sewing Machines	
Machine on silk and light goods	0.066 to 0.125
Machine on medium material	0.166
Machine on cloth	0.25
Machine on furs	0.25
Machine on carpets	0.25
Sheet Metal	
Crimping machines	2
Blanking press	1
10-ft. shear, No. 9 iron	10
No. 10 gauge cornice, press	10
48-in. multiple punch	7.5
Iron roofing press	5
Metal painting machine	2
One corrugating roll machine	5
Shoe Factories	
Crimping machine	0.5
Sole trimmer	1 to 5
Edge setter	1
Sandpaper wheel and blower	0.3
Grinder and buffer	0.5
Buffing machine	0.1
Hadaway stitch separator	0.3
Double buffer and blower	0.5
Special splitter	0.6
Leather roller	0.2
Stewart bus counter molder	0.6
Sole rounder	0.8
Stanley leather splitter	0.6
Fifield tip skiver	0.3
Smith stiffening skiver	0.1
Dinker	0.1
Scorer	0.1
Knox beam dinker	0.2
Knox end splitter	0.6
Small skiver	0.3
Knox twin molder	0.8
Goodyear channel hip turner	0.1
Fisher channel turner	0.1
Goodyear channeler	0.06

115. Horsepower required to drive Various Machines (*Continued*)
(Lloyd Assoc. Edison Ill. Cos., 1905)

Service	Required Hp.	Service	Required Hp.
[illegible] — Cont.		*Stone Works* — Cont.	
[illegible]	0.06	[illegible]0-in. circular stone saw	7.5
[illegible]	1.5	Stone planer	5
[illegible]	1.5	[illegible]-blade stone saw	15
[illegible]	1	Slow speed slate circular saw	2 to 5
[illegible]	[illegible]	Slate band saw	1
[illegible]	[illegible]	Marble drill press	1 to 3
[illegible]	[illegible]	Slate drill press	1 to 3
[illegible]	[illegible]	Pug mill	25
[illegible]	[illegible]	Tile grinder	2
[illegible]	[illegible]	Clay crusher	15
[illegible]	[illegible]	Marble surface grinder	10
[illegible]	[illegible]	*Structural Steel and Boiler Works*	
[illegible]	[illegible]	[illegible]-in. hole in [illegible]-in. steel (punches)	1
[illegible]	[illegible]	[illegible]-in. hole in [illegible]-in. steel (punches)	3
[illegible]	[illegible]	[illegible]-in. hole in [illegible]-in. steel (punches)	5
[illegible]	[illegible]	[illegible]-in. hole in 1-in. steel (punches)	7.5
[illegible]	[illegible]	*Shears*	
[illegible]	[illegible]	[illegible]-in. steel	1 to 3
[illegible]	[illegible]	[illegible]-in. steel	7.5
[illegible]	[illegible]	[illegible]-in. steel	10
[illegible]	[illegible]	[illegible]-in. horizontal shear	20
[illegible]	[illegible]	[illegible] angle shear	5
[illegible]	[illegible]	[illegible] angle shear	10
[illegible]	[illegible]	[illegible] gate shear	30
[illegible]	[illegible]	[illegible] machine, [illegible]-in. [illegible]	7.5
[illegible]	[illegible]	[illegible]	5 to 15
[illegible]	[illegible]	[illegible] shear	20
[illegible]	[illegible]	[illegible] column planer [illegible]	10
[illegible]	[illegible]	[illegible] bending roll	3 to 50
[illegible]	[illegible]	[illegible] straightening machine [illegible]	5
[illegible]	[illegible]	[illegible] straightening machine [illegible]	15
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	5
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible] hammers	[illegible]
[illegible]	[illegible]	[illegible] hammers	[illegible]
[illegible]	[illegible]	[illegible] shear	[illegible]
[illegible]	[illegible]	[illegible] machine	[illegible]
[illegible]	[illegible]	[illegible] machine	[illegible]

. HORSEPOWER REQUIRED TO DRIVE VARIOUS MACHINES
(*Concluded*)
(Lloyd Assoc. Edison Ill. Cos., 1905)

SERVICE	REQUIRED HP.	SERVICE	REQUIRED HP.
Machinery		*Wood-working Machinery*	
cutter	5 to 13	— Cont.	
roaster	10	Wood lathe	1 to 5
)bacco cutter	10	Wood boring machine	1
	2	1.75-in. double spindle	
	2	shaper	7.5
packer	0.5	9-in. sticker	7.5
leaf stem roller	20	8-in. buzz planer and	
		joiner	1 to 1.5
rking Machinery		12-in. buzz planer and	
chers or mold-		joiner	1.5 to 2
ıchines	3 to 5	16-in. buzz planer and	
:hers or mold-		joiner	2 to 3
ıchines	5 to 7.5	24-in. buzz planer and	
:hers or mold-		joiner	3 to 4
ıchines	7.5 to 10	30-in. buzz planer and	
:hers or mold-		joiner	4 to 5
ıchines	10 to 15	Planer and matcher	6 to 10
rface planer	3.5 to 7.5	Double and single surface	
ıurface planer	7.5 to 15	planers	7.5 to 15
;, double end	7.5 to 15	24-in. planer	15
;, single end	2 to 5	36-in. planer	25
ıscut saw	1	30-in. one drum sander	3
)sscut saw	2	30-in. two drum sander	3.5
)sscut saw	3	30-in. three drum sander	5
)sscut saw	5	42-in. one drum sander	5
)sscut saw	7.5	42-in. two drum sander	7.5
)sscut saw	10	60-in. three drum sander	10
)sscut saw	15	72-in. three drum sander	15
saw	1	Box board matchers	2 to 3
) saw	3	Dado machines	1 to 2
) saw	5	Dove tailers	2 to 3
) saw	10	Dowel machines	0.5 to 0.75
) saw	20	Miter machines	1 to 2
) saw	35	Box nailer	0.75
nd saw	1	Bit mortisers	1 to 2
band saw, 1-in.		Large box dove tailer	25
	2	Small box dove tailer	10
v, 2-in. saw	5	Sash mortisers	1 to 2
small work	1	Hollow chisel mortisers	2 to 3
nachine	10	Power mortisers	2 to 4
aw	1	Inside molders	7.5 to 10
rver	2	Outside molders	5 to 7.5
; and mortising		Panel raisers	1 to 3
ıes	3	Surface sanders	1 to 2
:r	1	Horizontal edger	2
der	1	Box dresser	1
	1	Large nailer	1.5

22. HOTELS
Dish washers
Dough mixers
Exhaust fans
Ice and refrigerating machines
Ice-cream freezers
Knife grinders
Laundry machines
Meat choppers
Pitcher cleaners
Ventilating fans

23. JEWELERS
Blowers
Buffs
Lap wheels
Lathes
Ring machines
Ventilating fans

24. KNIT GOODS
Braiders
Button machines
Knitting machines
Looms
Sewing machines
Ventilating fans
Whips

25. NEWSPAPERS
Blowers
Fans
Form hoists
Linotypes
Pneumatic tubes
Presses
Routers
Saws

26. OPTICIANS
Blowers
Drills
Exhaust fans
Grindstones
Lap wheels

27. PAPER BOXES
Automatic box machines
Die machines
Fans (drying and ventilating)
Presses
Saws
Whips

28. PAPER DEALERS
Fans
Gumming machines
Paper cutters
Perforators
Ruling machines
Whips or hoists

29. PRINTERS
Cylinder presses
Form elevators
Job presses
Linotypes
Paper and form hoists
Paper cutters
Ruling machines
Stitchers
Type bar machines
Ventilating fans

30. REPAIR SHOPS
Fans
Forge blowers
Sundry machinery
Whips

31. RESTAURANTS
Coffee grinders
Dough mixers
Grindstones
Ice-cream machines
Knife cleanser
Laundry machiner
Meat choppers
Pitcher cleaners
Ventilating fans

32. SALOONS AND CAFÉS
Ice-cream freezers
Ventilating fans

33. SHOEMAKERS
Buttonhole machines
Edgers
Goodyear machinery
McKay machinery
Rollers
Sewing machines
Skivers

34. SHIRTWAIST AND DRESSMAKERS
Cloth cutters
Fans
Sewing machines

35. SILVERSMITHS
Blowers
Buffs
Drills
Fans
Lathes

36. STATIONERS
Fans
Paper cutters
Perforators
Printing presses
Ruling machines
Whips or hoists

37. TAILORS
Cloth cutters
Fans
Sewing machines

38. TIN AND BRASS WARE
Blowers
Buffs
Drop press
Fans
Grinders
Presses
Punches
Straighteners for wire and plate

39. TOBACCONISTS
Cleaners
Cutters
Fans — exhaust and ventilating
Hoists and whips
Presses
Shredders

40. UMBRELLAS AND CANES
Buffs
Lathes
Presses
Saws
Sewing machines

COST OF CENTRAL STATION SERVICE COMPARED WITH THAT OF ISOLATED PLANTS

130. Installation costs of central station service include, generally speaking, the cost of necessary motors and their installation, the latter including the setting up of the motors on proper foundations, wiring connections between the motors and the central station service lines, starting rheostats or speed controllers, inspection fees, and possible changes in shafting, belts, and pulleys. It is to be assumed that central station solicitors will be provided with motor price lists, and that they, or others in the employment of the central station company, will be qualified to figure the other costs indicated above.

131. In **isolated steam plants** it is necessary to install boilers, engines, pumps, steam pipes, shafting, etc., — as well as one or more dynamos, if the plant includes the generation of electric energy.

132. It should be the duty of central station solicitors to inform themselves of the actual **costs** in their respective localities **of** the various **apparatus** named below, but the following designated costs, although only roughly approximate, should be of value in offhand figuring; or, when knowledge of actual costs is not at hand (installations of 300 hp. or less considered).

(*a*)	Return tubular boilers installed . . .	$10 to	$12 per hp.
	Water tube boilers installed	14 to	16 per hp.
	Scotch marine boilers installed	15 to	18 per hp.
(*b*)	Simple throttling engines installed . .	5 to	10 per hp.
	Simple high-speed engines installed . .	10 to	15 per hp.
	Simple Corliss engines installed . . .	20 to	25 per hp.

Condensing engines cost additional 30 per cent (about)
Compound engines cost additional 50 per cent (about)

c) Boiler-feed and house pumps, say, each . $500 to 250 per hp.
d) Dynamos . . . . 20 to 25 per kw.

e) Direct-connected dynamoes and engines cost from 35 to 50 per cent more than belted.
f) Steam piping costs average . . . . . 2 to 3 per hp.

133. DIFFERENCES IN NET COST BETWEEN SMALLER STANDARD DIRECT-CURRENT MOTORS AND GAS ENGINES [1]

DIRECT-CURRENT MOTORS		GAS ENGINES	
Horsepower	Cost	Horsepower	Cost
1	$ 60	1.5	$ 90 to $110
2	96	2	120 to 137
3	123	3	144
5	151	5	216 to 275
7.5	188	8	270 to 330
10	236	10	375 to 385
15	340	15	470 to 550

134. Installation costs over and above the bare cost of the motor or engine also average less in the case of electric motors than for gas motors, and the former can, besides, be installed wherever desired for service in the building.

135. Operating costs to users of central station service depend upon a variety of conditions: the central station's rates of charge for energy; upon the size and character of the user's installation, and the consequent amount of energy consumed, and also upon the user's load factor. The solicitor should see to it that a consumer's installation be made as efficient as possible, through the use of the proper number and sizes of motors, proper motor speeds, proper motor control, and highest motor efficiencies.

136. In determining the **cost of operating a steam or gas-engine plant** of any kind, the following items, or so many of them as apply in any particular instance, should be taken into account. Otherwise a proper comparison with central station electric service costs cannot be made.

[1] Differences in weight and floor space occupied account for difference in the price of gas engines of same horsepower referred to in the table.

137. The **items of cost** enumerated below do not apply in all cases of power use, for in many buildings floor space is rented with power service included, — or power may be furnished from an outside source, in which latter case the charge made for the energy so furnished and the expense of maintaining the drive inside are about the only cost items to be considered.

Items

Superintendence.
Salary of engineers.
  of firemen.
  of electricians.
Fuel.
Removal of ashes.
Water.
Oil.
Repairs to boilers.
Repairs to engines and dynamos.
Lamps.
Carbons.
Tool account.
Miscellaneous expense and supplies.
  Waste, packing, etc.
General expense.
Depreciation 10 per cent to 15 per cent.
Interest on investment 5 to 6 per cent.
Liability and fire insurance and taxes 2 per cent.
Rental value of space.
Damage resulting from heat and vibration.

138. Coal Consumption of Various Types of Engines per Indicated Horsepower-hour under Average (not Special or Constant Full-load) Running Conditions

Small vertical engines	14 to 18 lb. of good coal
Plain slide valve engines	10 to 12 lb. of good coal
High-speed automatic engines	8 to 10 lb. of good coal
Simple Corliss engines	6 to 8 lb. of good coal
Best types of multi-expansion condensing *engines utilizing* superheated steam	3 to 5 lb. of good coal

139. In figuring the expense of **operating a gas or gasoline engine plant**, liberal allowances should be made for interruptions in service (which ordinarily are frequent, and sometimes of several hours' duration), for the large repair expense usually necessary, and for rapid depreciation. Experience has shown that it is not safe in such cases to estimate the annual average maintenance (repair) and depreciation charges at less than 20 to 25 per cent. High maintenance and depreciation charges apply fully as well — in fact, more strongly because of the addition of the gas-producing apparatus — to producer-gas plants, and the latter are, furthermore, subject to an especially heavy interest charge because of the large investment necessary for a complete and operative installation. Solicitors should inform themselves on this last point in particular. It is true that fuel costs for both gas engines and producer-gas power plants are, ordinarily, low, but the other and increased charges are serious matters.

140. In spite of any statements to the contrary, it is practically necessary to have a **skilled attendant** look after the operation of gas engines or **producer-gas power plants**.

141. In cases where the plant is an electric generating plant, and is generating electric energy for both lighting and power service, the additional element of the lighting service has, of course, to be taken into account in figuring comparative installation and operating costs.

142. In figuring against isolated electric generating plant costs it is good practice to **install test meters** to determine the amount of energy consumed for light and power purposes respectively, and ordinarily no objection is made to such a test. If test meters are not installed, ammeter readings and voltages may often be obtained from isolated plant operators. In the absence of any wattmeter or ammeter readings, the number of lamps and average hours of burning, together with the number of motors, sizes of motors, average hours of running, and average loads should be ascertained as fully as possible.

SECTION 6

ELECTRIC VEHICLE ENGINEERING

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ELECTRIC VEHICLE ENGINEERING

INTRODUCTION

1. When **the electric automobile** first made its appearance, its many points of excellence, its reliability, and its safety were instantly recognized.

2. The question naturally arose, however, **which was superior, an electric or a gasoline propelled car**? The answer seemed to depend, at that time, upon comparisons of first cost and maintenance. Other questions were raised upon the comparative values of the two types in cost per mile for operating, and the dependence that might be placed in batteries compared with the gasoline engine. An electric to-day is judged **upon its own merits.**

3. When the automobile is discussed, **reliability** is a term of broad significance, for it includes **simplicity of control and operation.** No vehicle shows less complication or is more easily mastered than an electric. Its simplicity and economical operation make it an **ideal car for shopping, theater, commercial, and all city and suburban work.**

4. The electric automobile has recently made some **fine records for cross-country runs**, and it is probable that its field will be greatly extended in the near future. **Batteries** have been lightened by improvements in their construction, and the durability of the whole equipment inspires confidence of the user.

TALKING POINTS

5. Cost of maintenance means much with other cars, but is a simple proposition with an electric. Special consideration should be given to this point. Electric cars *are primarily for* and the park. They are the

cars of good form as well as utility. They are seldom handled with the stress and roughness which the heavy touring car is built to meet, and it follows, therefore, that one important class of repairs is seldom needed. **Tires last longer**, and **damage to mechanism** seldom occurs. With other forms of power one is momentarily in dread of the unexpected. The trouble may be in the engine, the fuel, the tires, or the lubricant. Come it does, with unpleasant regularity. It may be something that the driver can cope with at the expense of time, temper, and personal convenience, or it may be that he must be ignominiously towed to the nearest shop. The electric, however, **has fewer elements to be considered**, and it has been built throughout with an eye to reliability.

6. The electric must not be considered a fair-weather car. It is quite the contrary. It is, as a matter of fact, the **only satisfactory car throughout the whole year**. This is because it has no water to freeze, no lubricant to grow heavy at low temperature, and if desired, it can be closed more tightly against wintry blasts than any other form of vehicle. Its extreme simplicity, its readiness to go at any time and under any conditions, make it the **ideal car for disagreeable weather**, and gives one more instance in which the electric must be taken as the criterion for judging other cars. These characteristics especially commend this car to the **use of physicians** and others whose daily work or profession demands travel at all seasons.

7. In **industrial and manufacturing establishments** the electric machine fits in so harmoniously as to require very little argument in its favor. There is in such plants a quality of **mechanical ability** quite competent to take care of its upkeep, and its simplicity of control renders possible the availability of a number of operators for each machine, thereby insuring constant service. Furthermore, its power equipment may be so harnessed up as to provide mechanical **means for loading**, consequently reducing the time necessary for this performance and increasing the total utility of the machine and operator, in some cases by several hours per day.

8. **An economic feature** also to be borne in mind is that *when the machine* stops or is delayed at shipping depots,

its cost of maintenance also stops (except overhead charges), which is not the case with horse employment.

9. If the machine is not required for service during any considerable period, and its operator can be employed otherwise, **the maintenance costs subside correspondingly.** In this regard its employment or disuse is analogous to that of any other piece of machinery or portion of plant.

10. One peculiarity in machine performance has been difficult of conception to those unable to free their minds from horse usage, and this is, that the **consumption of current, tires, gears, and battery material** is in direct proportion to the work performed, and that the renewal periodically of such consumed material is as much an essential part of the programme as is the renewal of horse-shoes, wheel tires, feed, blankets, or any similar material requiring constant renewal with horse service. The periodic renewal of this consumed material has been regarded by those unaccustomed to analysis as the gradual breakdown or depreciation of the entire vehicle, whereas **the machine proper undergoes very slight wear**, and the annual depreciation is somewhere between 5 and 10 per cent per annum, as is evidenced by the installations which have been in service for the past ten years.

11. One electric vehicle in delivery service does the **work of at least two horse-drawn vehicles** and eliminates the reserve horses in the stable.

12. A four-story garage twenty-five feet wide, one hundred feet deep, will store one hundred electric vehicles. A four-story stable, to accommodate the necessary horses and wagons to do the same work, is five times as wide.

13. Electric vehicles are run into the shipping room, **carried by elevators from floor to floor**, facilitating loading service, — a method in every way preferable to horses and wagons backed against the curb for an entire block. There is no fire risk connected with an electric machine.

14. There is simply nothing to do but **turn on the current and steer the machine. There is no delay**, no troublesome routine to go through, no hard cranking with its ever present danger from back-firing. The current is turned on just as you would light an incandescent lamp, and is obedient to its lever.

15. An electric will go forty miles to seventy-five miles on one charge of battery, which is more than is needed in a day's business.

16. An electric can be recharged at night in six hours' time.

17. Horses can do but five or six miles an hour under normal conditions, while the electric wagon can do ten, and it does not require feed or water.

18. With an equal carrying capacity and the higher speed you can **handle fifty per cent more goods with electrics**.

19. The space required is about half of that required for an equal number of horses and wagons. Where real estate is costly this is vitally important.

20. An **electric garage can easily be kept as clean as your own home.** It is a much harder proposition with a stable.

21. Because of the smaller space required and the **absence of stable odors**, it is possible to keep electrics in or adjacent to the store.

22. There may be **a few isolated cases** where there is no economical advantage in motor vehicle delivery, but these cases are exceptional instances. Where the work to be done is less than half the ability of the machine, proper value may not be derived from the investment, but in most cases the operator of a few delivery wagons, and a couple of trucks and two or three heavy drays, can profit at once by replacing them with electrics, as his expense will be much less for a given service. Where a large number of vehicles is used the advantages of electricity become more apparent, and **the efficiency of the service is improved** still more.

23. The space occupied by the electric wagon is small, the running rapid, the capacity large, the handling simple, the operation accurate and easy, so that in every way it is distinctly a saving and a convenience.

24. Merchant stables, transfer companies, and manufacturers doing their own teaming alike have felt the cost of feed for stables full of idle horses which have been "eating their heads off," and in those situations where commercial vehicles have been owned in conjunction with horse vehicles, the owner has found the inanimate machine in sharp contrast to the cost and work and **worry of the stables.**

25. To the horse owner there is always the consciousness of feed and proper care necessary merely that life, to a proper physical standard, be kept in the horse. **The idle horse** may not consume quite so much feed as does the horse hard at work, but in his idleness the matter of feeding must be more carefully looked after if the animal shall not suffer from the enforced confinement. Many a careless or ignorant owner of horses has let no more than a couple of idle days pass without restrictions as to feed for his animals, and on the next working day has had his **horses dropping dead** in the streets or paralyzed beyond hope of cure.

26. At any time and season the **horse in idleness is a double risk and cost to his owner.** In the season of midsummer, when brassy skies overhead and reflection from burning walls and pavements at the best cut the activities of the horse by 50 per cent, this chance of idleness is doubly menacing. In every city a season of unusual heat is marked by horses dropping dead or incapacitated and ruined in the hot streets, to say nothing of the attendant cruelty that comes of working these animals under such conditions.

27. In times such as these the man working the motor truck experiences a sense of relief that is unknown to the driver of the horse vehicle. If idleness be imposed upon the commercial vehicle, its owner runs it into its accustomed shelter, certain that until he takes it out again it will be no further charge upon him for maintenance; certain that while it is resting, there is no possibility of depreciation so long as it is protected from the elements; and, more than all, confident that, no matter what the excessive heat of the streets, he can depend upon the machine for its maximum of activity and with no tax upon his sympathies.

28. Here at once is a **tremendous cumulative responsibility** upon owner and caretaker of the horse which is not felt by the man depending upon the motor truck. The team owner may try to persuade himself that in using the horse he has learned to accept the conditions under which the animal lives and has its being.

29. In a time of general depression, with feed for the horse at an abnormally high fig[illegible] a stableman

housing his one truck has had this comparison with the horse brought home to him as he has not felt it before. This one inevitable comparison under such conditions may account for much of the present inquiry which has been marked in the Government Post Office Department, in the police and fire departments of the cities, and by the metropolitan newspapers of the country. It is one of the most absurd of anomalies in connection with the horse that he should cost almost as much for keep and tax his caretaker even more in times of idleness than in his busiest season of work. It is a situation of itself incompatible with the exercise of true business principles. Save for ages of adaptation to the horse, the condition might reduce the business of the express and van companies to an intolerable absurdity.

DEVELOPMENT OF THE COMMERCIAL VEHICLE

30. Recognizing that the **electric automobile** is becoming an **accepted adjunct to the transportation of merchandise** in our large cities to-day, it may be well to give a brief history of its development up to the present time.

31. Nearly all of the **earlier vehicles** of the larger size were **driven by motors mounted on the rear axle**, the method of transmission being usually of the single reduction spur-gear type. In the smaller sizes, such as runabouts, live rear axles with differentials and single motors were used; while in the larger sizes two motors and dead rear axles were employed. Some of these features, adopted at the beginning of the industry, were excellent and are successfully used to-day by the most capable builders.

32. The **method of control adopted** in these earlier types was what is known as the commutated battery system, the controller changing the connections of various sets of cells from parallel to series, thereby varying the speed of the vehicle by varying the impressed e. m. f. on the motor. **The main disadvantage** of this method of control was the unequal discharge of the different battery sets when connected in multiple. The **mileage of these earlier vehicles**

was quite low compared with the results obtained to-day from the same size battery, the reason being that the friction, or, in other words, the wattage, was excessively high.

33. It has been shown that **motors mounted directly on the rear axle** are necessarily of low speed, are comparatively heavy, and their efficiency on overloads not high: and further that the transmission under average conditions is not very efficient. A great deal of experimenting and investigation made by a prominent electric automobile builder along this line during the past few years has shown that to obtain the maximum vehicle efficiency, **the weight below the springs must be reduced** as much as possible.

34. Next in order came **the double-reduction motor,** mounted on or suspended from the body of the vehicle, the power being transmitted from the countershaft (or in some cases where slow speed, single-reduction motors were used, from the motor shaft) to the rear wheels by means of chains and sprockets. The vehicle efficiency of this type of transmission was found to be higher than the direct spur-geared type, due to the increased flexibility in the driving mechanism, less weight on driving axle, better distribution of total weight and the use of lighter, higher speed, and more efficient motor.

35. In 1903 one company placed on the market **a new and lighter type of commercial vehicle**, the principal features of which were: —

Net weight approximately 0.6 of that of any vehicle of similar carrying capacity previously built.

Flexible armored wood frame.

Single motor, with roller-chain drive from motor to countershaft.

Double-chain drive from countershaft to rear wheels.

VALUE OF FLEXIBILITY OF TRANSMISSION PARTS

36. Although this vehicle, in the smaller sizes, was *capable of carrying* nearly its own weight, it was found to

...ry in service. This was due to
... the **running gear and transmission**
... this type of vehicle that it proved
...ght could be reduced considerably
... vehicles, without impairing the
... the cost of maintenance.
... these lines, some of the standard
... equipped with a single motor and
..., as well as double motors with the

... **metal tires** are used it may become
... road conditions to get more trac-
... drive affords. Under these condi-
... **drive is preferable**, also under condi-
... snow or muddy roads if all four wheels
... can pull out of places, when equipped
... might be very difficult for a two-

... **frames** are used for the smaller size
... channel frames are employed for the
... frames being so designed as to retain
... and strength without increasing

... been made in the **design of motors**,
... increased on normal and overloads
... unnecessary weight has been re-
... the speed torque characteristics
... taking their energy from storage
... is that the vehicle efficiency has
... creased.

... the **controlling apparatus** has also
... this new condition. The **standard**
... commutate the battery, but to
... of the motors with proper shunt-
... greater number of speeds at higher

... types of vehicles, the controller
... between controller points, the
... burning of contacts, and expensive
... motor, and tires.
... has been brought out which ob-

these troubles and increases the mileage and
's and batteries. This controller is so designed
or circuit is not opened at any point from the
st, the torque on the motor never falling be-
n predetermined value. It is known as the
torque controller" and is applicable to both
uble-motor equipments.

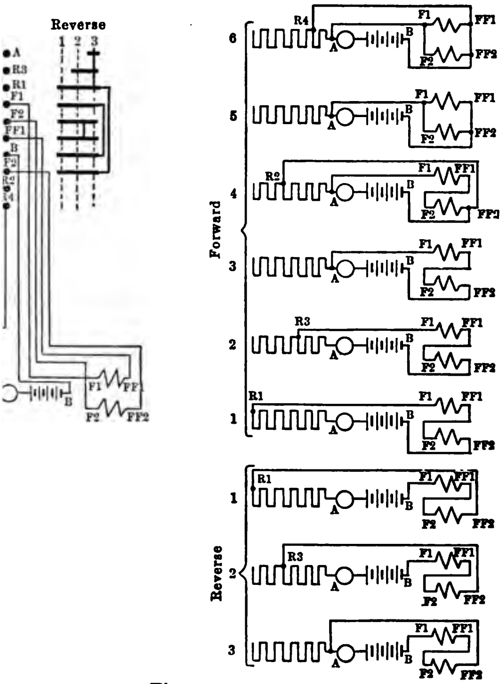

Fig. 1.

s 1 and 2 show **typical connections** of two late
trollers. Figure 3 shows the **speed torque**
automobile motor of recent type.

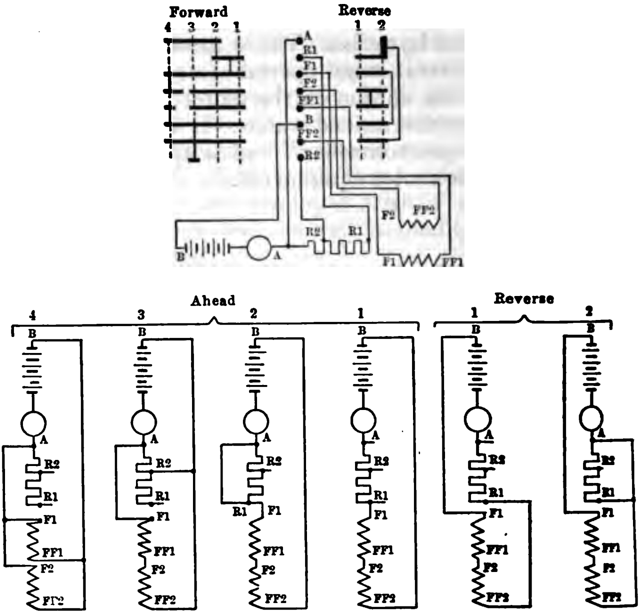

Fig. 2.

OPERATING AND MAINTAINING THE ELECTRIC VEHICLE

45. The following instructions were recently issued as representative of the requirements for **the proper care and maintenance of electric vehicles.**

46. The **operation and care of an electric automobile** is no more of a task than driving and stabling a horse equipment. Use judgment in driving. **Do not overload nor overspeed.** Keep the vehicle and its power plant clean and in good adjustment. Keep the battery in good condition and properly charged. Keep all nuts and bolts tight, especially on the clips connecting the springs *and frame.*

CONTROLLER

47. **The controller cylinder**, under the seat, is revolved by a handle on the seat. Turning the controller changes the electrical connections of the motor and varies the speed of the vehicle, similar to a street-car controller.

48. In **starting**, time must be allowed for the car to attain a certain speed before moving the controller to the next speed point. No pause should be made *between* points, and the **car should not run longer than necessary on the first and second points**, which include a resistance in series with the motor.

49. Do not keep the **controller handle in continuous motion**, as this is unnecessary and increases the wear and strain on all parts of the vehicle.

50. Always **open the main switch and set the brakes before** leaving the vehicle. This disconnects the motor and bell from the battery and prevents the vehicle from starting alone.

51. Occasionally **oil the controller shaft** and all bearings in the controller operating mechanism.

52. Keep the **surfaces of the controller segments** or contact block clean and bright with fine sandpaper. Use a slight amount of vaseline, and wipe off all but the little required to keep the segments bright and smooth.

53. When **working on the controller**, it is well to disconnect one side of the battery to prevent accidental short circuiting.

54. See that the **controller fingers** give a fair amount of pressure on the cylinder segments and bear evenly across their width. The fingers may be fitted to the segment by moving a strip of sandpaper between the segment and the finger (sanded side against the finger). Be careful not to sand so much surface that it will bridge the gaps between the sections of a ring or segment, and thus make improper connection of different running points.

55. If the controller has **adjusting screws** for regulating the drop of the finger between the segments, see that this drop is about $\frac{3}{32}$ inch. This is especially important on the last or running point of the controller. It need not be *considered on a* controller having fiber bridges between the

segments, where no drop is necessary. In all cases **firm pressure** and **good contact** should be maintained.

56. Do not allow waste, tools, etc., to accumulate under the controller.

MOTORS

57. The only parts of a motor needing attention are the **commutator, brushes, and the bearings**. Each motor should be inspected at least once a week and the commutator should be examined when the motor is running with rear wheels jacked up to detect any sparking which may be due to a dirty or worn commutator or broken brush. The commutator, brushes, and brush holder should at all times be kept perfectly clean. The **commutator may be lubricated** slightly with a very little vaseline applied with a clean cloth while the motor is running.

58. The **commutator in normal condition** presents a smooth, brownish surface. If blackening appears after operation, it may be due to sparking or wearing. The remedy is easily applied when the trouble is located. If brushes are too loose, increase the spring tension. If **brushes** are badly burned, broken, worn down, or make poor contact, replace them with new brushes, sandpaper to a good fit, and smooth the commutator surface with sandpaper while running. Use No. 1 or No. 2 sandpaper. **Do not use emery.** If brushes are tight or welded in holder and do not work freely on commutator surface, put in new brushes or refit old brushes. If **commutator becomes badly worn** or shows irregularity, it should be renewed or turned down to a smooth, even surface in a lathe. If commutator is slotted between segments, it should be reslotted after turning down to remove copper burrs from segment edges.

59. **If the commutator flashes**, it may be caused by a broken wire or coil, producing a greenish flame and burning the two bars diametrically opposite each other. This burning should be stopped by putting a jumper of solder or small wire across the burned bar, connecting the two adjacent bars to each other until a complete examination can be made and the broken connection permanently repaired. ***A flare at the commutator*** may be caused by a short cir-

uited field or a field coil improperly connected. **A short ircuited field coil** can be located by testing the voltage drop ı the coils by means of a voltmeter. **An incorrect field onnection** can be detected by a pocket compass which will

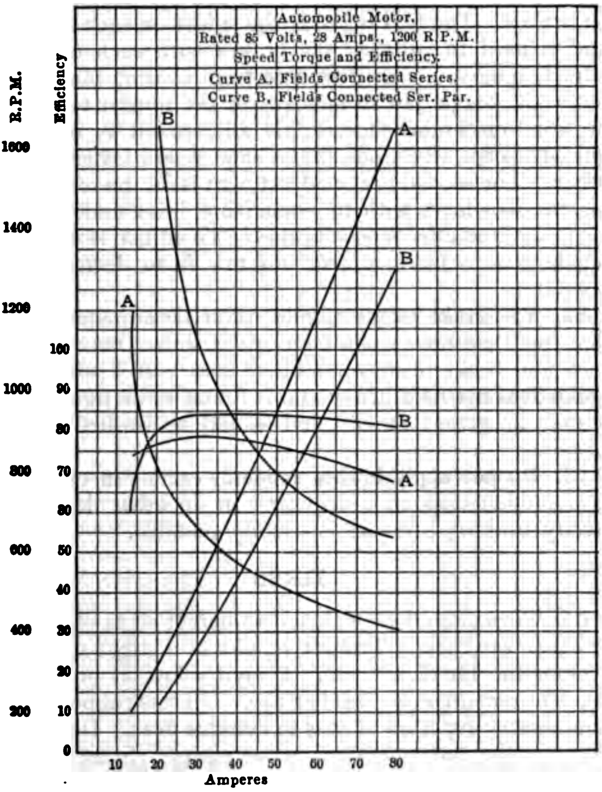

Fig. 3.

ıow adjacent fields to have the same polarity if fields are ıcorrectly connected. Alternate fields should be north and ›uth *when field* connections are correct.

BRAKES

60. Examine the brakes every morning. The brake band is faced with leather, which must be renewed before wearing down to the brake band.

61. Two adjustments are provided for taking up wear on brakes. The first is inside the spider on each rear wheel and is used to equalize the brakes with each other. To adjust, remove cotter pins, free from bearing pin, and unscrew the toggle jaw to increase, or the reverse to decrease, pressure on brake shoe. This adjustment is seldom required except when one brake shoe wears faster than the other. The second brake adjustment is on the rod connecting the foot lever with the equalizing lever under the rear of the car and affects both brakes. To adjust, screw on the toggle jaw to increase, and unscrew it to decrease, brake pressure.

62. **The brake toggle** should never be adjusted so tight that less than one-eighth inch space shows between brake shoe and brake drum when brake is in " off " position. **If brake does not hold firmly** and is found to be tight enough, it may be greasy or oily and should be washed out with gasoline.

63. **Do not apply brakes suddenly** except in emergency, as a sudden stop may strip tires or do other damage. A steady braking pressure is usually possible.

TIRES

64. Tires should be watched to detect signs of looseness or other weakness. Prompt repairs of a slight nature will prolong the life of the tire. Do not allow oil or grease to reach or remain on any rubber tire. Oil rots rubber. **Avoid unnecessary exposure of tires to extreme heat.** Do not keep them in the hot sun when unnecessary. Start and stop gradually. Strains are bad for tires as for anything else. Avoid running in car tracks. It is hard on tires.

CHAINS

65. Once every month take off the **chains** driving the wheels, wash in kerosene until clean, then soak in hot tallow

or heavy grease. No other lubrication is needed here. These chains should show some slack when running, but not much. Too loose or too tight chains may jump off, stretch, wear out, or run hard. Motor chains should be lubricated twice weekly with a heavy grease. Engine grease No. 2, made by the Vacuum Oil Company, is recommended.

BEARINGS

66. The **bearings** on the motors and on the wheels and countershafts are properly adjusted before leaving the factory.

67. They will probably need no further attention for six months, except to clean in kerosene or gasoline and repack with non-fluid oil No. K-000 once a month, or oftener if inspection shows this to be necessary.

68. Do not set up the **wheel bearing** so tight it resists rotation; keep it slightly slack. The wheels should be adjusted so that a little end shake can be felt, just enough to show the bearing is not jammed. Loosening the axle nut one-half turn after the wheel is set up tight is usually sufficient.

69. In some makes the **countershaft bearings** may be adjusted for wear by adding thin steel adjusting washers between bearing cones and sprockets. These should be obtained from the maker. With **sprockets** off both ends, adjust one end until just a little end shake can be felt with sprocket on this end. Then adjust the other end by adding washers until the shaft turns hard after the sprocket is drawn up tight. Then take off this sprocket, remove one washer, and replace the sprocket.

70. In single motor types the **differential** should receive the same inspection and lubrication as the bearings. Screw down the **grease cup** one turn every morning, and oil other parts twice weekly.

71. Do not use graphite. Do not take a bearing apart. Do not let acid get into a bearing. Do not believe the man who says that bearings will run safely without oil or grease.

STEERING GEAR

72. Keep all **steering gear bearings** properly lubricated. The sector shaft bearing is oiled from the top by re-

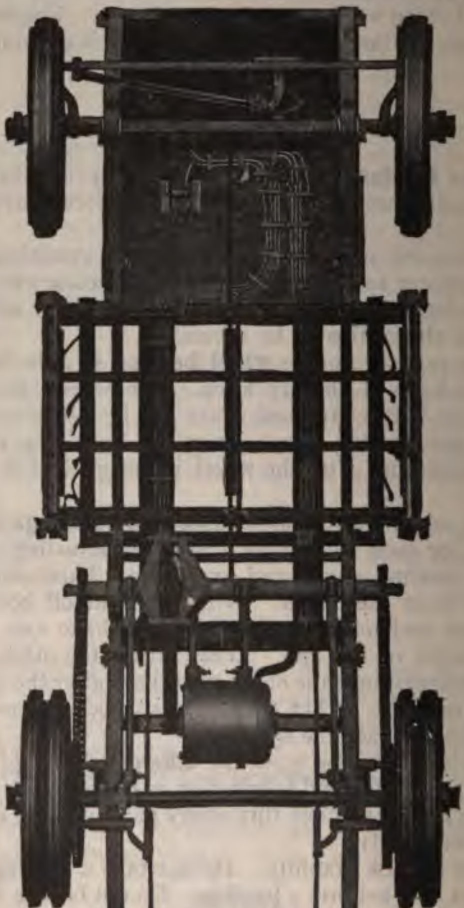

Fig. 4.

moving oil cup cover. Pinion and sector should be well lubricated with heavy grease. Remove the upright steering head pins on either end of the front axle about once a month and wash in kerosene. Keep all nuts and joints in good adjustment, to prevent lost motion.

73. Figure 4 shows a representative **chassis**. The motor, controller, steering, and transmission gear are plainly shown.

STORAGE BATTERIES[1]

74. The storage battery of commerce is made up with electrodes having their active material of lead peroxide (PbO_2) and sponge lead (Pb), as the positive and negative electrodes respectively, immersed in a dilute solution of sulphuric acid (H_2SO_4).

75. When fully charged and in good condition, **the positive plates** have a dark reddish-brown or chocolate color, while **the negatives** are gray or slate-colored. The plates may be readily distinguished by their colors and also by the character of the active material. The **lead peroxide** is hard like soapstone, while the negative material is soft and can be easily cut into with the finger nail. **The negative material** is pure lead which has been reduced to a sponge-like form.

76. On **discharge**, the electrolyte combines with the active materials of the electrodes, and on charge the active materials are reduced to their original condition, **the chemicals** extracted from the electrolyte being released and returned to it. From this it follows that the **density of the electrolyte** is greater at the end of charge than at the end of discharge, and also that the active material on the plates expands as discharge proceeds. **The chemical formula** for the actions above set forth is: —

$$PbO_2 + Pb + 2\,H_2SO_4 \underset{\xrightarrow{\text{Discharge}}}{\overset{\xleftarrow{\text{Charge}}}{=}} 2\,PbSO_4 + 2\,H_2O$$

Read from left to right, it shows the reaction on discharge, while from right to left the reactions produced by the charg-

[1] *Extract from* "Standard Handbook for Electrical Engineers."

ing current are indicated. It shows that on discharge SO_3 is abstracted from the H_2SO_4, which combines with the positive and negative active material to form lead sulphate ($PbSO_4$) and water (H_2O), while in charge the chemical action of the current releases the SO_3, restoring the plates to their previous active condition.

77. **The unit of capacity** of any storage cell is the ampere-hour and is generally based on the eight-hour rate of discharge. Thus a one-hundred-ampere-hour battery will give a continuous discharge of twelve and one half amperes for eight hours. Theoretically it should give a discharge of twenty-five amperes continuously for four hours, or fifty amperes for two hours. As a matter of fact, however, the ampere-hour capacity decreases with an increase of discharge rate.

78. **The capacity of a cell** is proportional to the exposed area of the plates to which the electrolyte has access, and depends on the quantity of the active material of these parts.

79. Theoretically **the weight of metallic lead** on either element, reduced to sponge lead or to lead peroxide, required to produce one ampere-hour of discharge is 0.135 ounce avoirdupois; if converted into peroxide, this will weigh 0.156 ounce. In practice, however, the **weight of active material** required per element is from four to six times the theoretical, for the reason that it is impossible to reduce all the active material to bring every particle into contact with the electrolyte; or to cause every part to be penetrated by the current. Experiments show that from 0.50 to 0.80 ounce of sponge lead, and from 0.53 to 0.86 ounce of metallic lead converted into peroxide, are required on their respective elements to produce a discharge of one ampere-hour at ordinary commercial rates.

80. **The capacity of batteries** depends, therefore, on the size and number of plates in parallel, their character, the rate of discharge, and also on the temperature. Taking the eight-hour rate of discharge and the temperature of 60° F. as standard, the capacities which obtain in American practice are from forty to sixty ampere-hours per square foot of positive plate surface (*i. e.* no. of positive plates in parallel × length × breadth × 2).

81. ***The voltage* of any storage** cell depends only on the

racter of the electrodes, the electrolytic density, and the dition of the cell, and is independent of the size of the cell.

2. The voltage of the **lead sulphuric acid cell** when being rged is from 2 to 2.5 volts, while on discharge it varies n 2.0 down to 1.7 volts.

3. **High battery voltages** are obtained by joining the

FIG. 5.—The Electric Storage Battery Company's Type "M V" 13 Cell.

uired number of cells in series. Thus to obtain an electrotive force of one hundred volts, approximately fifty cells series are required. The voltage of a cell under any dition of charge varies with the density of the electrolyte l to a certain extent with the temperature.

'he **troubles to which batteries are most commonly sub-** are :—

. Loss of capacity.

. Loss of voltage.

Corrosion of electrodes.

4. Distortion and fracture.
5. Shedding of active material.

Nearly all of these except the third are directly traceable to overdischarge, although overcharge and impurities in the electrolyte are important factors.

84. Sulphation. — As has been shown, on discharge that portion of the active material which enters into the chemical combination with the electrolyte is reduced to lead sul-

FIG. 6. — The Electric Storage Battery Company's Single Tray of Five Cells.

phate. This substance, when pure, is white, is a non-conductor, and occupies a much greater volume than the pure lead or lead peroxide which forms it.

85. Battery discharge is usually stopped at a point where a comparatively small part of the active material has been converted into sulphate. This sulphate being mixed with the uncombined active material, the whole mass retains its conductivity to a large extent and does not expand to a harmful degree if provision is made for a reasonable amount of expansion. If discharge is prolonged, however, beyond the proper point, its effects are over-*sulphation,* which manifests itself in a variety of ways.

86. Figures 5 and 6 illustrate two types of electric vehicle storage batteries.

THE CARE OF AUTOMOBILE STORAGE BATTERIES

87. Intelligent observation of approved methods of **battery maintenance** will result in efficient service, and demonstrate the superiority of the electric vehicle in all fields to which it is adapted.

88. All **storage battery manufacturers** give complete and **detailed instructions** on the operation and care of their batteries, but such instructions are not the same for all types of batteries. The following refers particularly to " Exide " batteries: —

89. Charging current, in all cases, should be direct. If **an alternating current circuit** only is available, direct current may be obtained by means of **a mercury arc rectifier**, or a motor generator set, the former being more efficient for the purpose.

90. Suitable **charging apparatus** should be obtained and installed by a competent electrician, or by the vehicle manufacturer.

91. To charge the batteries place the controller handle and vehicle switches in the position given in instructions furnished with the vehicle.

92. Open the battery compartment to obtain as much **ventilation** as possible. If the cells can be reached, remove the rubber plugs from the covers.

93. Do not bring a **naked flame near the cells** while charging, or immediately afterwards. Accumulated gas is apt to explode.

94. All **lamps on vehicle** must be turned off while charging, as, if in use, they are apt to be burned out by the increased voltage. The bell should not be rung.

95. With the battery switch on the switchboard open, and with all resistance in, place the charging plug in its receptacle on the body of the vehicle, close the battery switch, and by moving the rheostat handle and watching the ammeter adjust the current to the proper starting rate. All battery manufacturers furnish **instruction books on *charging rates*.** These instructions should be strictly

adhered to. For example, if the battery to be charged consists of twenty-four cells of 9 PV Exide, the charge should be started at nineteen amperes, and kept at that rate until the voltmeter indicates sixty-one volts, then reduce the rate to eight amperes and keep it there until the voltage, which fell when the rate was reduced, stops rising, or, in other words, reaches a maximum. This **maximum** will, in general, be approximately the same as the voltage at which the rate of charge must be reduced.

96. The **time required for a charge** will depend upon the amount of the previous discharge. If this has been two-thirds of the capacity of the battery, about three hours at the starting rate and an hour and a half at the finishing rate will be necessary. If the battery has been discharged to the extent of 75 per cent, about six hours will be necessary for the recharge.

97. When the vehicle is to be **charged at night from a rectifier**, the regulator may be placed in position and the battery left to charge without further attention, as the current will continue to enter the battery until it is completely charged, then the rectifier will automatically cut off.

98. If, **in case of an emergency**, it is desired to charge the battery more quickly than usual, a higher rate than normal, never exceeding 50 per cent over the starting rate, may be used.

99. Care should be taken to **fully charge the battery**, but it must not be excessively overcharged. **Much injury may be done** by pounding a nearly full battery at a high rate.

100. After completing the charge, and before disconnecting the battery from the switchboard, **always turn the rheostat handle back**, before opening the battery switch.

101. Batteries are sometimes **charged too frequently**. For instance, if a battery will run a vehicle forty miles on one charge, and the vehicle is run five miles, then charged, taken out again, run nineteen miles and charged again, then is given another run of ten miles and is charged, the vehicle has been run only thirty-four miles, but has been charged four times.

102. The greatest **wear on the plates** of a battery occurs *during the final* part of the charge. In treating the battery

as above it was charged three times oftener than necessary, and then did not make the mileage it was capable of on one full charge. In other words, when a vehicle is in daily use for short runs, money is saved on the current bill and the life of the plates is prolonged if the battery is not charged until 75 per cent of its capacity has been exhausted.

103. The battery should be inspected regularly, not less than once a week. Even if no adjustments are found necessary, the inspection should not be neglected.

104. To get the best results from a battery, it should never be discharged below 1.70 volts per cell, with the vehicle running at full speed on level ground.

ELECTROLYTE

105. Caution should be taken against the use of **acid** for batteries that has not had the approval of the battery manufacturers. Many have taken **oil of vitriol**, 1835° specific gravity, or 66° Baume, and mixed their own battery solution. This practice is bad, as no acid can be greater than 1400° without carrying impurities with it. These **impurities** are iron, lead, and other metals. Confine the use of the strong acid to your burning outfits exclusively. Use nothing stronger than 1400°, and that only upon approval of its purity and under the direction of the battery manufacturers. This is one of the things that **must not** be looked upon lightly.

BRIEF REMINDERS ON CARE OF BATTERIES

106. Paste these in your hat! Post them on the battery compartment lid or door! Stick them on the charging switchboard! and try to imprint them upon the brain of the man responsible for the care of your vehicle.

107. While they tell and instruct much, they suggest more, and any concern supplying batteries will gladly furnish the fullest detail in their amplification.

A battery must always be charged in the right direction and "direct" current used.

108. Be careful to **charge at the proper rates** and to give the right amount of charge: do not undercharge or overcharge *to an excessive* degree.

109. Do not bring a **naked flame near the battery** while charging or immediately afterwards.

110. Do not overdischarge.

111. Do not allow the battery to **stand completely discharged.**

112. **Voltage readings** should be taken only when the battery is charging or discharging. If taken when the battery is standing idle, they are of little or no value.

113. Do not allow battery temperature to exceed 100° F.

114. Keep **the electrolyte** at the proper height above the top of the plates and at the proper specific gravity. Use only pure water to replace evaporation. **Never use acid,** except under conditions as explained in **105.**

115. Keep the cells **free from dirt** and all foreign substances both solid and liquid.

116. Keep the battery and **all connections clean.** Keep all bolted connections tight.

If there is a lack of capacity in a battery, due to low cells, do not delay in locating and bringing them back to condition.

117. Do not allow sediment to get up to the plates.

MERCURY ARC RECTIFIERS

118. With the introduction of the **mercury arc rectifier** it is possible to obtain direct current from alternating at a low cost, because the regulation is obtained from the alternating side of the rectifier, while the current comes from the direct-current side. The mercury arc rectifier is a unique piece of apparatus. **The theory** is as follows: —

119. In an **exhausted tube** having one or more **mercury electrodes**, ionized vapor is supplied by the negative electrode or cathode, when the latter is in a state of "excitation." This condition of excitation can be kept up only as long as there is current flowing towards the **negative lectrode.** If the **direction of the voltage** is reversed, so the formerly negative electrode is now positive, the nt ceases to flow, since in order to flow **in the** opposite ion it would require the formation of a new negative rode, which can be accomplished only by special means. erefore, the **current is always flowing towards one elec-** 'e *cathode*, which is kept excited by the current

'. Such a tube would cease to operate on alternating-
ent voltage after half a cycle if some means were not
ided to maintain a flow of current continuously towards
legative electrode.

0. In the General Electric rectifier tube there are **two
hite electrodes** (anodes), A, A, and **one mercury cathode,**
'ig. 7). Each anode is connected to a separate side of
ılternating-current supply and also through reactances
ıe side of the load. The cathode is connected to the
r side of the load. As the current alternates **first one
e and then the other becomes positive,** and there is a
inuous flow of current towards the cathode, thence
ıgh the load and back to the opposite side of the supply
ıgh a reactance. **At each reversal the reactances dis-
ge,** thus maintain-
the arc until the
ıge reaches the
e required to main-
the current against
counter e. m. f. of
load, and also re-
ng the fluctuations
ıe direct current.
ıis way **a true con-
ous current** is pro-
d with very small
in transformation.

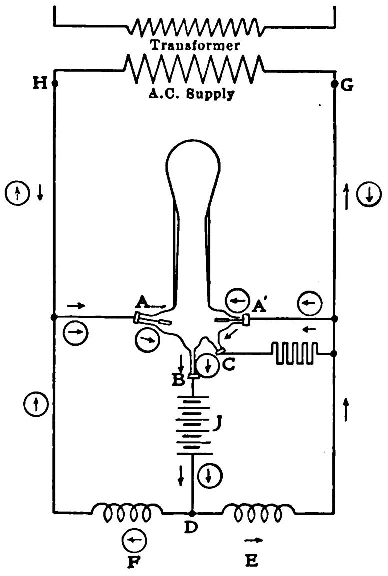

Fig. 7.

1. A small elec-
e, C, connected to
ide of the alternat-
urrent circuit is
for **starting the arc.**
ight **tilting of the**
makes a mercury
ge between B and C
draws an arc as
as the tube returns
vertical position.

2. The panel shown in Figure 8 is intended for charg-
a number of automobiles in electric garages. While
exact method will differ with the cond

consists briefly in charging a number of vehicle batterie in series and others in multiple. The best combination i easily obtained by a simple calculation, and this metho

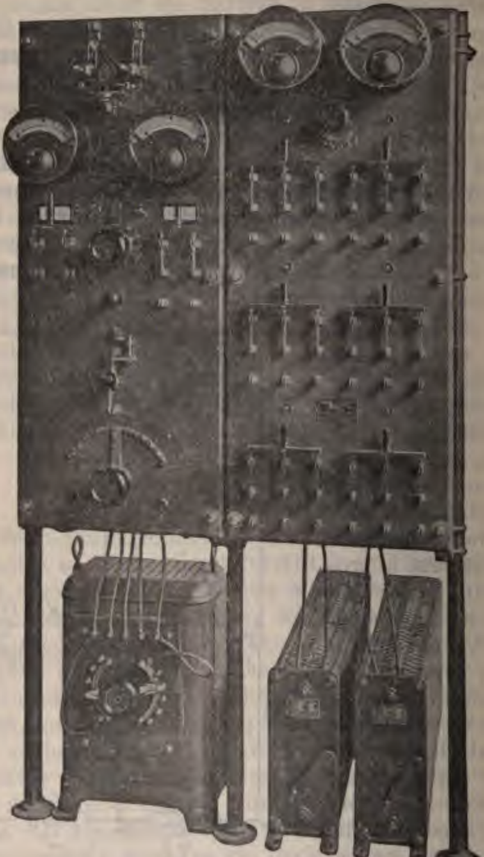

Fig. 8. — General Electric Mercury Arc Garage Panels.

will be found very efficient in either small or large garage The panel illustrated is manufactured by the General Ele *tric Company.*

WESTINGHOUSE MERCURY RECTIFIERS

3. The Westinghouse Electric and Manufacturing pany have devised several types of mercury rectifier ery-charging outfits to fulfill various conditions of service. The type A, which is especially designed for ging automobile storage batteries is described below.

FIG. 9. — Westinghouse Type A Mercury Rectifier.

4. **The charging of storage batteries** for the electric mobile is one of the handicaps with which this desir- *type of vehicle* has suffered. It has required more or

less expert attention, such as the individual owner is rarely prepared to give, which usually means the return of the vehicle to the garage. The type "A" mercury rectifier outfit (Fig. 9), recently placed on the market, is designed to overcome the charging difficulties commonly met with, as it is an outfit which can be readily adjusted for charging any particular battery and which is entirely automatic in its operation. With this new mercury rectifier outfit it is only necessary to **set the regulating dial pointers** according to the table in the instruction card on the outfit. After this has once been done no readjustment is necessary during the progress of the charge or from charge to charge. **In regular charging** it is simply necessary that the rectifier outfit be cut into the vehicle battery and the primary current supply switch closed. The mercury rectifier is immediately started, automatically, and proceeds to supply direct current, charging the battery.

125. The type "A" rectifier outfit is not only self-starting when primary switch is closed, but if at any time the current is interrupted during the charge, it automatically stops itself until the battery reaches a point where it is cut out by the completion of the battery charge.

126. This permits the individual owner to run the vehicle into his private garage, connect it up with the type "A" Westinghouse mercury rectifier, close the primary switch, and go to bed, knowing that in the morning he will find his automobile with the battery fully charged, all ready for operation, he merely having to open the primary switch and disconnect the battery from the rectifier outfit.

127. When there is no danger of momentary interruption in the primary circuit, the type "A" rectifier outfit can be furnished without the automatic starting features, if so desired. This outfit has the other characteristics of gradually cutting down the current as the voltage of the battery cells rise, and cutting out automatically when the charge is completed, and it differs from the type "A" automatic outfit only in requiring the bulb of the rectifier to be tilted by hand in order to start it.

131. HOW TO COMPARE THE USE OF HORSES WITH THE USE OF ELECTRIC VEHICLES

HORSE EQUIPMENT

Investment

...........Horses		@	$..............
agons:			
.... 1-horse		@	....
.... 2-horse		@	....
rucks:			
.... 2-horse		@	....
.... 4-horse		@	....
ther vehicles:			
....		@	....
....		@	....
....		@	....
arness:			
.... Single		@	....
.... Double		@	....
.... 3-horse		@	....
.... 4-horse		@	....
.... 6-horse		@	....
lankets, robes, etc.			....
eal estate			....
table tools and fittings			....
ther investment			....
Total investment			$..............
nterest on above @ ......%			$..............
nsurance			....
epreciation:			
Horses ......%	$............		
Wagons ......%	....		
Trucks ......%	....		
Other vehicles ......%	....		
Harness ......%	....		
Blankets, etc. ......%	....		
Building ......%	....		
Tools and fixtures ....%	....		
Total depreciation			....
perating expenses:			
Oats, hay, straw, etc.			....
Shoeing			....
Veterinary service			....
Replacing tools and fittings			....
Replacing blankets, robes, etc.			....
Repairing vehicles			....

Operating expenses:
- Repairing harness ....
- Repairing building ....
- Labor, foremen ....
- Labor: stablemen ....
  - miscellaneous ....
  - teamsters ....
  - helpers ....
- Licenses ....
- Miscellaneous expense ....

Total annual expense $..............

132. ELECTRIC VEHICLE EQUIPMENT

Information necessary before proper selection can be made: —

Weight of initial load.
Number of trips required.
Distance outgoing loaded.
Number of packages (average).
Distance returning trip.
Are packages collected on return?
How far from starting point before deliveries are begun?
Are packages bulky?
What are the street conditions?

133. TABLE OF INVESTMENT AND EXPENSE

"The following tabulation of investment and expense is submitted to serve as a guide to industrial executives to make a comparison of the amount of horse work which the machine may be capable of performing in and around their plants. Without knowing the vital features of operating conditions it would be impossible to predict accurately the operating expense in any specific case.

134. "The figures given herewith are in two groups, one intended to cover 'ordinary' service, where the load is transported only a portion of the entire distance traveled, and the other to cover 'maximum' conditions in such cases wherein the load is carried the total distance, as in the transfer of outgoing material from factory to freight stations, and on return trip the transfer of incoming freight to the factory."

MAXIMUM HEAVY SERVICE

:hicles: rrying in lb.	800 lb.	1500 lb.	2500 lb.	4000 lb.	7000 lb.	10,000 lb.
:ost of . .	$1850.00	$2300.00	$2800.00	$3250.00	$3700.00	$4500.00
nent .	64.93	95.67	148.51	162.51	188.00	225.64
. .	$1914.93	$2395.67	$2948.51	$3412.51	$3888.00	$4725.64
1 de- (less d tires)	$258.06	$317.68	$369.50	$423.90	$481.58	$589.58
s, and . .	79.27	117.35	210.00	408.45	691.42	805.35
and epairs	84.28	106.43	126.73	141.82	162.33	202.95
:newal ings .	197.64	283.80	438.25	490.05	562.26	628.98
ırrent, ıt 6 ct. . .	168.28	270.00	414.00	552.60	630.00	709.20
. .	$787.53	$1095.26	$1558.48	$2016.82	$2527.59	$2936.06

ORDINARY LIGHT SERVICE

hicles: rying 1 lb. .	800 lb.	1500 lb.	2500 lb.	4000 lb.	7000 lb.	10,000 lb.
cost .e . .	$1850.00	$2300.00	$2800.00	$3250.00	$3700.00	$4500.00
ment .	64.93	95.67	148.51	162.51	188.00	225.64
. .	$1914.93	$2395.67	$2948.51	$3412.51	$3888.00	$4725.64
d de- (less d tires)	$258.06	$317.68	$369.50	$423.90	$481.58	$589.58
s, and . . .	31.71	35.56	84.00	133.65	230.45	268.45
and epairs	49.30	61.89	72.96	81.86	93.58	126.76
newal ings .	98.82	141.90	219.14	245.02	281.13	314.49
ırrent, .t 6 ct. . .	168.28	270.00	414.00	552.60	630.00	709.20
. .	$606.17	$827.03	$1159.60	$1437.03	$1716.74	$2008.48

he price per kilowatt-hour should be changed to suit local conditions.

an example of what may be expected from auto-
ıder proper conditions and with intelligent man-
the figures in tables **136** and **137** merit careful
ɔn. They are extracted from a report made by the
f the traffic department to the board of an express
ınd *embody* a comparison between the number.

cost, and operating expense of the horse-drawn veh required to perform a certain work and the number, and operating expense of automobiles accomplishing same work. The figures are compiled from actual s and garage accounts, and are authoritative.

136. THE HORSE SERVICE

Cost of Fifty-three Double Wagons

39 3-ton wagons at $373	$14
5 2-ton wagons at $329.43	1
9 1-ton wagons at $379.10	3
212 horses at $220	46
53 sets double harness at $45	2
	$68

Annual Operating Expenses

Interest on $68,631.65 at 5 per cent	$3
Depreciation:	
Wagons, $19,606.05, at 10 per cent	1
Horses, $46,640.00, at 13 per cent	6
Harness, $2,385.00, at 14 per cent	
Feed and labor:	
212 horses at $26.70 per month	67
53 drivers at $65.00 per month	41
53 helpers at $45.00 per month	28
	$149

137. THE ELECTRIC VEHICLE SERVICE

Cost of Forty Electric Trucks

10 3-ton trucks at $3,600	$3
Extra battery	
30 2-ton trucks at $3,400	10
3 extra batteries at $376.20	
Fittings for 10 trucks at $100	
	$14

Annual Operating Expenses

Interest on $140,570.80 at 5 per cent	$
Depreciation:	
Trucks, less tires and batteries:	
$110,742 at 10 per cent	1

ttery trays, jars, and fittings:	
$2,978.80 at 10 per cent	297.88
ttery plates, $14,300, at 75 per cent	10,725.00
ires, $11,550, at 125 per cent	14,437.50
ent and labor:	
omplete charge, 313 days:	
3-ton trucks, 26 kilowatts, at 4 cents	3,255.20
2-ton trucks, 20 kilowatts, at 4 cents	7,512.00
rage help, 5 men	4,080.00
drivers at $65 per month	31,200.00
helpers at $45 per month	21,600.00
	$111,210.32
Saving in favor of electric trucks	$38,463.73
Or 25.7%.	

Schedules A, B, C, and D, following, show the method computing comparative costs between Horse and Automobile operation in a specific case where the same work as to be accomplished by each equipment.

138. SCHEDULE "A"

Horse Transportation Analysis

NVESTMENT:

60 Horses @ $200	$12,000.00	
20 Route Wagons @ $280	5,600.00	
2 Supply Wagons @ $300	600.00	
25 Double Harness Sets @ $70	1,750.00	
Stable Equipment	1,200.00	
		$21,150.00

NNUAL OPERATING EXPENSE:

Interest, $21,150.00 @ 6%	$1,269.00
Depreciation, Repair, and Replacement Horses, Wagons, and Harness, $19,900 @ 15%	2,985.00
Stable Equipment, $1,200 @ 10%	120.00

MAINTENANCE AND LABOR:

Feed (at stable):	
60 Horses @ 45 ct. × 305 days	$8,235.00
Pasturing:	
60 Horses @ .1667 ct. × 60 days	600.00
Shoeing:	
60 Horses @ 7½ ct. × 365 days	1,642.50

Stable Charges:		
60 Horses @ 55 ct. × 365 days . .	12,045.00	
(This latter includes Labor, Rent, Insurance, Light, Heat, and Water)		
Annual Operating Expense, less drivers	$26,896.50	$[illegible]

$\frac{\$26,896}{365} = \$73.69$ Expense per Day.

Drivers as per Schedule "C"	[illegible]
Total Annual Operating Expense	$[illegible]

139. SCHEDULE "B"

Automobile Prospectus

Investment:

10 2000-lb. Machines @ $3,700 Approx.	$37,000.00	
10 Extra Bat. 44/17 MV. @ $840 Approx.	8,400.00	
Apparatus for Charging and Maintenance	1,200.00	
		$[illegible]

Annual Operating Expense:

Interest — $[illegible] @ 6%	$2,796.00	
Depreciation (Sinking Fund): Machines, less Batteries and Tires, $[illegible] @ 5%	1,371.50	
Apparatus for Charging and Maintenance, $1,200 @ 5%	60.00	
		$[illegible]
Annual Fixed Charges	$4,227.50	

Maintenance, Replacement, and Labor:

	Dec.–Feb.	Mar.–Apr.	[illegible]
Batteries: Cleaning and Renewals	$201.[illegible]	$522.38	[illegible]
Tires: Repairs and Renewals	[illegible].80	230.47	
Mechanical and Elec. Repairs	102.[illegible]	157.15	
Current @ [illegible] ct. per kw.-h. . . .	[illegible]	466.00	
Garage Help, Rent, etc. . . .	480.00	480.00	
	$1,40[illegible]	$1,856.00	$[illegible]
Proportion of Fixed Charges .	[illegible]	704.58	
Maintenance Expense. [illegible]	$[illegible]	$[illegible]	$[illegible]

[illegible]

DRIVERS:

2 Men per Machine @ $3.75: Drivers Expense—$8,872.50 =	877.50	1,170.00	6,825.00
Total Annual Expense: $27,726.99 . . . . . =	$3,432.58	$3,712.58	$20,581.83

EXAMPLE:

To add 2 Machines and two (2) Batteries for May-Nov. Service: increase May-Nov. Total Annual Expense by 20% and increase proportion of Fixed Charges in other columns by 20%			
Thus: Total $4,468.62 . . =	211.36	140.90	4,116.36
Increase, $32,195.61 . . . =	$3,643.94	$3,853.48	24,698.16

140. SCHEDULE "C"

COMPARATIVE ANALYSIS

HORSE TRANSPORTATION			MAINTENANCE		
Period	Days	Exp.	Dec.-Feb.	Mar.-Apr.	May-Nov.
Dec.-Jan.-Feb. .	90 @	73.69	$6,632.00		
March-April .	61 @	73.69		$4,495.00	
May-Nov. . .	214 @	73.69			$15,769.00
Exp. Maintenance		$26,896.00			

Period	Days Wagons Cost		LABOR:	
Dec.-Jan.-Feb.	78 × 6 × 3.75	1,755.00		
March-April .	52 × 12 × 3.75			
March 1 supply Wagons .	52 × 1 × 1.75		2,431.00	
May-Nov.. .	182 × 20 × 3.75			
May 2 supply Wagon . .	182 × 2 × 1.75			14,287.00
Expense Drivers	$18,473.00			
Total Horse Exp.	$45,369.00	$8,387.00	$6,926.00	$30,056.00

AUTOMOBILE TRANSPORTATION: MAINTENANCE:

Period	Days	Expenses			
Dec.-Jan.-Feb.	90	Sch. "B"	$2,555.08		
March-April	61	Sch. "B"		$2,542.58	
May-Nov. .	214	Sch. "B"			$13,7
Exp. Maintenance		$18,854.49			

Period	Wk.	Mar.	Cost		LABOR:	
Dec.-Jan.-Feb.	78	3	3.75	877.50		
March-April .	52	6	3.75		1,170.00	
May-Nov. . .	182	10	3.75			6,(
Expense Drivers .			$8,872.50			
Total Machine Exp.			$27,726.99	$3,432.58	$3,712.58	$20,:

ANNUAL SAVING:

By Machines *vs.* Horses, $17,642.01 = $4,954.42 $3,213.42 $9,

If the machine equipment above provided for has to be increased during the May-Nov. period by two additional machines with two extra batteries, the saving shown will be reduced by (see Report) $4,684.62 . . . . = 211.36 140.90 4,

141. SCHEDULE "D"

WORK PERFORMANCES OR LOAD CHARACTERISTICS

PRESENT HORSE METHOD

	No. Del. Routes	Mileage of Each Route	Del. per Day Each Route	No. Del. Veh.	Trips per Veh. from Sup. Depot	Vehicle Mileage per Trip	Vehicle Mileage per Day	Veh. Hrs. per Trip	Veh. Hrs. per Day	Veh. Load per Trip, lb.	Veh. Load per Day, lb.	Total Load per Day, lb.
Dec.-Feb.	6	8	1	6	1	8	8	12	12	6,000	6,000	36,000
Mar.-Apr.	12	6	1	12	1	6	6	10	10	5,000	5,000	60,000
May-Nov.	20	4.8	2	20	2	4.8	9.8	5	10	4,500	9,000	180,000

PROPOSED MACHINE METHOD

Dec.-Feb.	6	8	1	3	2	8	16	6	12	6,000	12,000	36,000
Mar.-Apr.	10	7.2	1	5	2	7.2	14.4	5	10	6,000	12,000	60,000
May-Nov.	16	6	2	8	4	6	24	3	10	5,625	22,500	180,000

ELECTRICAL DEFINITIONS AND INFORMATION OF DAILY USE TO THE ELECTRIC VEHICLE USER

Accumulator. — Storage battery.

Alternating Current. — That form of electric current the direction of flow of which reverses a given number of times per second.

Ammeter. — An instrument for measuring electric current.

Ampere. — Unit of current. It is the quantity of electricity which will flow through a resistance of one ohm under a potential of one volt.

Ampere-hour. — Quantity of electricity passed when electricity flows at the rate of one ampere for one hour.

Anode. — The positive terminal in a broken metallic circuit; the terminal connected to the carbon plate of a battery.

Armature. — That part of a dynamo or motor which carries the wires that are rotated in the magnetic field.

Branch Conductor. — A parallel or shunt conductor.

Brush. — The collector on a dynamo or motor which slides over the commutator or collector rings.

Busbars. — The heavy metallic bars to which dynamo leads are connected and to which the outgoing lines, measuring instruments, etc., are connected.

Buzzer. — An electric alarm similar to an electric bell, except that the vibrating member makes a buzzing sound instead of ringing a bell.

Candle Power. — Amount of light given off by a standard candle.

Capacity, Electric. — Relative ability of a conductor or system to retain an electric charge.

Charge. — The quantity of electricity present on the surface of a body or conductor.

Choking Coil. — Coil of high self-inductance.

Circuit. — Conducting path for electric current.

Circuit-breaker. — Apparatus for automatically opening a circuit.

Collector Rings. — The copper rings on an alternating-current dynamo or motor which are connected to the armature wires and over which the brushes slide.

Commutator. — A device for changing the direction of electric *currents.*

Condenser. — Apparatus for storing electricity.

Cut-out. — Appliance for removing any apparatus from a circuit.

Cycle. — Full period of alternation of an alternating-current circuit.

Diamagnetic. — Having a magnetic permeability inferior to that of air.

Dielectric. — A non-conductor.

Dimmer. — Resistance device for regulating the intensity of illumination of electric incandescent lamps. Used largely in theaters.

Direct Current. — Current continuously in one direction.

Dry Battery. — A form of open circuit battery in which the solutions are made practically solid by addition of glue jelly, gelatinous silica, etc.

Electrode. — Terminal of an open electric circuit.

Electrolysis. — Separation of a chemical compound into its elements by the action of the electric current.

Electromagnet. — A mass of iron which is magnetized by current through a coil of wire wound around the mass but insulated therefrom.

Electromotive Force. — Potential difference causing current.

Electroscope. — Instrument for detecting the presence of an electric charge.

Farad. — Unit of electric capacity.

Feeder. — A lead from a central station to some center of distribution.

Field of Force. — The space in the neighborhood of an attracting or repelling mass or system.

Fuse. — A short piece of conducting material of low melting point which is inserted in a circuit and which will melt and open the circuit when the current reaches a certain value.

Galvanometer. — Instrument for measuring current strength.

Generator. — Rotating machine for production of e. m. f.

Inductance. — The property of an electric circuit due to the lines of force which are developed around it.

Insulator. — Any substance impervious to the passage of electricity.

Kilowatt. — 1000 watts. (See watt.)

Kilowatt-hour. — 1000 watt-hours.

Leyden Jar. — Form of condenser which will store electricity.

Lightning Arrester. — Device which will permit the high-voltage lightning current to pass to earth, but will not allow the low-voltage current of the line to escape.

Motor-generator. — Motor and generator on the same shaft, for

changing alternating current to direct and *vice versa*, or changing current of high voltage and low intensity to current of low voltage and high intensity and *vice versa*.

Multiple. — Term expressing the connection of several pieces of electric apparatus in parallel with each other.

Multiple Circuits. — See parallel circuits.

Neutral Wire (direct current). — Central wire in a three-wire distribution system.

Ohm. — The unit of resistance. It is arbitrarily taken as the resistance of a column of mercury one square millimeter in cross sectional area and 106 centimeters in height.

Parallel Circuits. — Two or more conductors starting at a common point and ending at another common point.

Polarization. — The depriving of a voltaic cell of its proper electromotive force.

Potential. — Voltage.

Resistance. — The quality of an electrical conductor by virtue of which it opposes an electric current. The unit of resistance is the ohm.

Rheostat. — Resistance device for regulating the value of current.

Rotary Converter. — Machine for changing alternating current to direct current or *vice versa*.

Secondary Battery. — A battery whose positive and negative electrodes are deposited by current from a separate source of electricity.

Self-inductance. — Tendency of current in a single circuit to react upon itself and produce a retarding effect similar to inertia in matter.

Series. — Arrange in succession, as opposed to parallel or multiple arrangement.

Series Motor. — Motor whose field windings are in series with the armature.

Shunt. — A by-path in a circuit which is in parallel with the main circuit.

Shunt Motor. — Motor whose field windings are in parallel or shunt with the armature.

Solenoid. — An electrical conductor wound in a spiral and forming an electromagnet.

Spark gap. — Space between the two electrodes.

Storage Battery. — See secondary battery.

Thermostat. — Instrument which, when heated, closes an electric circuit.

ELECTRICAL DEFINITIONS AND INFORMATION

Transformer. — A device for stepping-up or stepping-down alternating current from low to high or high to low voltage, respectively.

Volt. — Unit of electromotive force or potential. It is the electromotive force which, if steadily applied to a conductor whose resistance is one ohm, will produce a current of one ampere.

Voltage. — Potential difference or electromotive force.

Voltmeter. — Instrument for measuring voltage.

Watt. — Unit representing the rate of work of electrical energy. It is the rate of work of one ampere under a potential of one volt. Seven hundred and forty-six watts represent one horsepower.

Watt-hour. — Electrical unit of work. Represents work done by one watt expended for one hour.

TERMS, NAMES, AND THEIR MEANING

First Type of Cell considered — Description of the Exide Battery Parts

Positive Plate. — Dark brown in color.

Negative Plate. — Dark gray in color.

Straps. — Are of molded lead with tapering rectangular openings, into which the lugs of the plates are burned.

Top or high-burned straight strap.

Top or high-burned plate strap.

Pillar strap.

Connectors. — Are of molded lead and are used for connecting adjacent cells equipped with pillar straps.

Lugs. — The portion of the frame of each plate which projects from its top.

Positive Group. — This consists of a number of positive plates, held together by one of the straps described above, and is distinguished by the dark or brownish color of the plates.

Negative Group. — This consists of a number of negative plates, held together by one of the straps described above, and is distinguished by the grayish or slate color of the plates.

Rubber Separators. — Are made of thin sheets of perforated hard rubber and are to be placed on both sides of each positive plate.

Wood Separators. — Are made of specially treated wood, grooved on one side, one being placed between each positive and negative plate, **with the flat side against the negative.**

Separator Hold-downs. — In cells equipped with pillar straps the

apron or fin extending from the bottom of the strap serves as a separator hold-down.

In cells equipped with top or high-burned straps four pieces of hard rubber are used, two thick and two thin; the thick pieces are placed at each side of the cell on the thin pieces, which rest across the top of the element, back of the plate lugs. The two thick pieces support the two-piece cover used with this strap.

A glass hold-down should be used in cells equipped with top straps when covers are not to be used.

Element. — This consists of one positive group, one negative group, and rubber and wood separators.

Hard Rubber Jar. — A vessel made of hard rubber to hold the element and electrolyte.

Hard Rubber Cover. — A piece of hard rubber cut to fit into the top of the jar, and provided with holes and slots for the rubber plug, and the straps or plate lugs.

Soft Rubber Plug. — Made of soft rubber to fit into the hole in the middle of the cover. It is removed when the electrolyte is to be tested or the cell examined; also during charging, when practicable.

Sealing Compound. — A plastic composition sometimes used to seal the rubber cover into the jar to prevent slopping and spilling of the electrolyte.

Electrolyte. — The fluid or solution in the cells, a mixture of especially pure sulphuric acid (oil of vitriol) and pure water (preferably distilled).

Complete Cell. — The element and electrolyte in a rubber jar with cover and soft rubber plug.

Terminal Connectors. — Lead lugs into which are cast cable or wire. They connect the free ends of a group of cells to the terminals.

Terminals. — Metal castings attached to the tray, from which the groups of cells are connected together and the battery to the controller.

Battery. — Any number of complete cells assembled. Usually an oak box, properly reënforced, with the wood treated to render it acid proof.

Tray. — The receptacle in which the cells are assembled in one or more trays.

Polarity Marks. — A cross (+) indicates positive and a dash (—) indicates negative.

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